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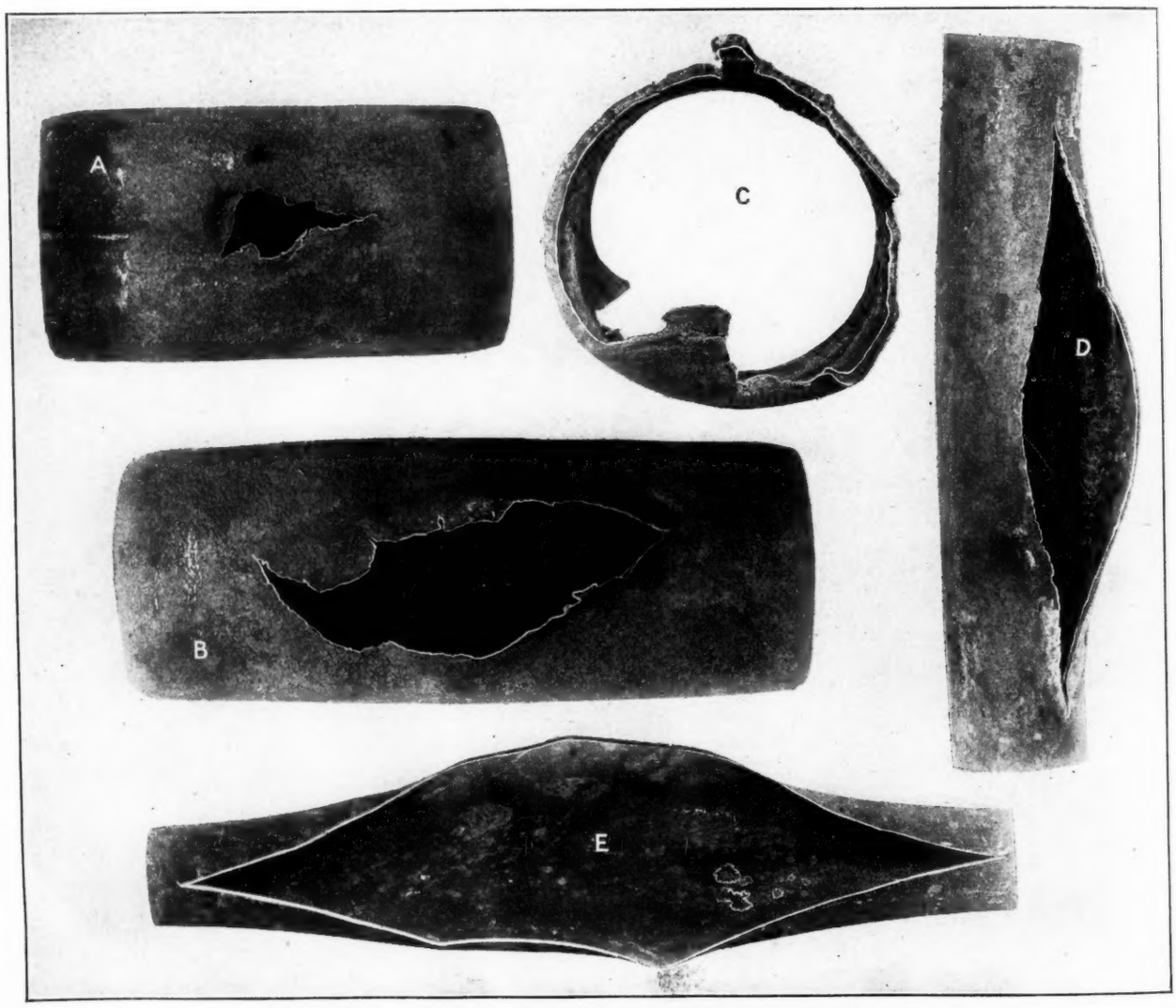
WHILE CONGRESS TALKS!

Water-Tube Boiler Tube Ruptures

By WELDON MELROY

A LARGE percentage of tube failures are unavoidable, but many ruptures may be prevented by the prompt renewal of tubes in which serious defects develop. The number of preventable tube ruptures has increased during the last year because the shortage of steel has made it imperative to get the maximum service from every tube. On account of this condition some operators have taken chances with tubes when they are not deep and the tubes are kept clean, such pockets are not considered serious. Tubes that become distorted to such an extent that the points of the pockets can be dented by a sharp blow from a light hammer should be renewed. Efforts to heat the distorted portions and drive them back to their original radius after they have been pocketed to such an extent that the walls have been thinned, are usually unsuccess-



TUBES FROM WATER-TUBE BOILER RUPTURED FROM SEVERAL CAUSES

Ruptures *A* and *B* caused by deposits of mud and scale. Ruptures *C* and *D* caused by crystallization. End view of tube shows condition of tube wall. Rupture *E* is of a 4-in. tube caused by a defective lap weld.

which have developed defects, and some serious ruptures have resulted.

At *A* and *B* (see illustration) are shown ruptures that were caused by overheating. The feed water used in the boiler in which these tubes were installed was very foul. The tubes that ruptured were found to contain considerable deposits of precipitated mud and organic matter, which was baked on the internal surfaces and caused the ruptures. Pockets caused by accumulations of scale and mud are frequent in water tubes, but ful, and there is considerable hazard in connection with operating tubes that have been treated in this manner.

At *C* and *D* are shown sections of a tube that became crystallized to such an extent that it ruptured without warning, causing considerable damage to the adjacent tubes and boiler setting. The end view of the tube shows the coarse crystalline structure of the metal. It will be observed that only a very narrow section of the tube wall at the inside edge was not crystallized. The ruptured edges of the tube show that the tube wall

was not thinned. In addition to the rupture the tube cracked in a number of places. One of these cracks is shown in the illustration. The tube end was so lacking in ductility that pieces could be broken off with a blow of a hammer.

In the illustration *A*, *B*, *C* and *D* show that seamless-drawn steel tubes will rupture from overheating or weakness caused by crystallization. In addition to being subject to these conditions, lap-welded tubes sometimes rupture on account of defective welds. Such ruptures are usually violent and cause serious damage. At *E* is shown a rupture of a lap-welded tube about four months after its installation, under a pressure of 140 lb. That the weld was defective is shown. The principal reason for the use of lap-welded tubes in water-tube boilers is the fact that under present conditions they are considerably cheaper than seamless-drawn tubes.

When the damage caused to boiler settings, the injuries suffered by the operating force in the boiler rooms and the interruption to the service caused by tube ruptures are considered, it will be seen that there is nothing gained by operating boilers in which there are tubes that are suspected of being defective. When tubes show signs of crystallization or become dangerously distorted, they should be renewed. Efforts to restore ductility to crystallized tubes by annealing or to drive back deep pockets are so uncertain that such measures cannot be considered safe or satisfactory methods of repair.

Effect of Interpoles on Commutation of Direct-Current Machines

By R. L. WITHAM
Assistant engineer, Sperry Gyroscope Co., Brooklyn, N. Y.

The construction of the interpole direct-current machines is described. The purpose of the interpoles and how they operate to effect commutation and how one interpole may be used for each pair of main poles to serve the same purpose as an interpole for each main pole are explained.

THE interpoles in a direct-current machine, when used, are small poles placed between the main poles. It is from their location that they get their name, the prefix "inter" meaning between or among. Direct-current machines may have as many interpoles as there are main poles, or they may have one interpole for each pair of main poles. Fig. 1 shows the field frame of a four-pole compound-wound interpole machine having one interpole *A* for each main pole *B*, where the machine Fig. 2 has only one interpole *A* for each pair of main poles *B*. The use of interpoles on direct-current machines is today almost universal. Ten or twelve years ago their use was a novelty. Yet the fundamental idea of which these commutating poles are but the materialization is by no means a new one. Why, then, have they come into such general use and how does their use affect the operation of the machine of which they are a part? To answer these questions it is necessary first to consider their purpose and in what manner it is fulfilled.

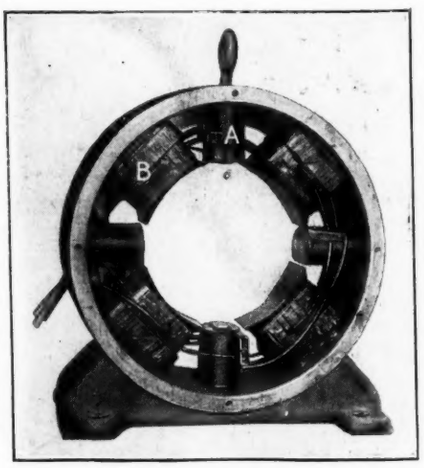


FIG. 1. FOUR-POLE MOTOR HAVING FOUR INTERPOLES

FIG. 2. FOUR-POLE MOTOR HAVING TWO INTERPOLES

Briefly stated, the purpose of interpoles is to assist in commutation. Because of this they are also known as commutating or auxiliary poles. In any direct-current machine the current in the armature coils is alternating; that is, while any one coil is passing across the face of a north pole of the machine it carries current in a certain direction, but that direction is reversed when the coil moves across the face of the next consecutive, or south, pole.

Fig. 3 represents diagrammatically a part of the winding of a direct-current armature, the small arrows showing the direction of current in the coils. Assuming that current flows downward in the conductors under a north pole, it will flow upward in the conductors under a south pole and in those midway between poles there will be no current. The armature is assumed to be moving from left to right as indicated by the large arrow. It will be seen that the direction of current in a coil which is approaching a brush (as for example, coil *A*) is clockwise, while the direction of current in a coil which has passed the brush (as for example, coil *C*) is counterclockwise. This shows that while the coil in question was passing under the brush, its current was reversed in direction. This reversal of current in the armature coil is what is known as commutation.

Assuming a brush 0.5 in. wide and a peripheral speed

of commutator of 2500 ft. per min., or 500 in. per sec., it will require 0.001 of a second for a given point on the commutator to travel the width of the brush, and in this brief period the current in a coil undergoing commutation must be reduced from its normal value to zero and be built up to its normal value again in the opposite direction if commutation is to take place without sparking. What force can be made to act upon the coil in such a way as to produce this change in current in so short a time? The way to produce any desired change in current in a coil is to set up an electromotive force in that coil, and the way to set up the required electromotive force is to so arrange conditions that the coil will cut lines of magnetic force of the proper polarity and strength.

The laws governing the generation of electromotive force and current by cutting lines of force is clearly explained in that part of "The Electrical Study Course" appearing in the Nov. 20, 1917, issue of *Power*. A glance at Fig. 3 will show that when a coil is in such a position that it is short-circuited by a brush (as for example, coil *B*) the conductors that compose that coil are midway between poles and at these midpoints the magnetic flux due to the poles is zero.

This condition is more clearly shown in Fig. 4, which represents the distribution of flux in the air gap between the poles and armature. In order to provide for this coil a magnetic flux of such strength and polarity that it will set up the electromotive force required to commutate its current either of two things may be done: (1) The brushes may be shifted until commutation takes place when the coil is in some such position as shown in Fig. 5, where the desired flux is furnished by the main pole; or (2) without shifting brushes, a set of small poles, known as commutating poles or interpoles, may be introduced midway between the main poles to provide the necessary flux at that point, as illustrated in Fig. 6. When the latter method is used, we have the interpole machine.

Having shown that the purpose of the interpole is to produce a commutating field midway between the main poles, consider next in what way the interpoles shall be supplied with the magnetizing current. If the interpole winding were excited from a source of constant potential, as is the case with the shunt-field winding, the commutating flux thus established would be constant regardless of the load on the machine. But this is not what is desired. If a machine is carrying a current of 200 amperes, it requires twice as strong a commutating field for perfect commutation as when the same machine carries 100 amperes. In other words, the strength of the commutating field should vary directly with the ampere load on the machine. This result is approximately accomplished by connecting the commutating winding in series with the armature winding and working the iron of the interpole at such a low magnetic density that it is always unsaturated. Then the armature current can be made to vary between wide limits and the commutating-field strength will vary with it, just as it should. The number of turns per coil of the interpole winding, the length of air gap and the width and shape of interpole face all have their effect on the

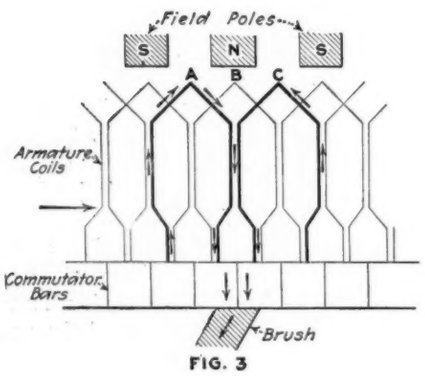


FIG. 3

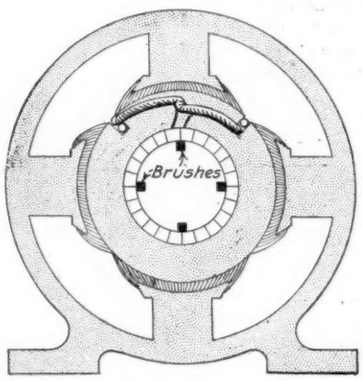


FIG. 4

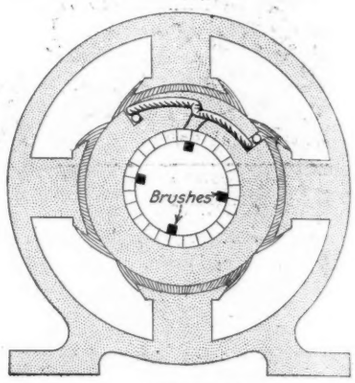


FIG. 5

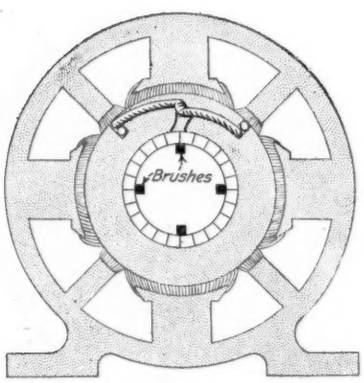


FIG. 6

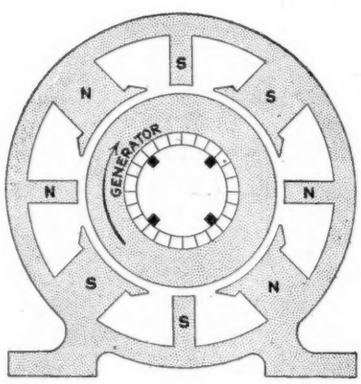


FIG. 7

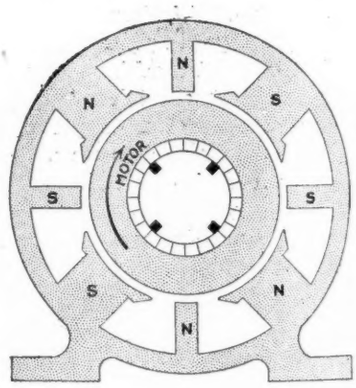


FIG. 8

FIGS. 3 TO 6. FIELD FRAMES OF NONINTERPOLE AND INTERPOLE DIRECT-CURRENT MACHINES

strength and distribution of commutating flux and hence upon commutation, but the proper adjustment of these elements is a matter for the designer of the machine to determine and will not be considered here.

Fig. 7 shows the polarity of the interpoles in the case of a generator and Fig. 8 that of a motor, the direction of rotation being taken as clockwise in both cases. If the direction of rotation is reversed, the polarity of the commutating poles should be reversed.

Fig. 9 represents a four-pole machine in which are shown the four armature coils which at a given instant are short-circuited by their respective brushes. Since coil 1 is made up of conductors lying in both slots *A* and *D*, an interpole placed at either *A* or *D* will have the effect of setting up the flux needed for commutating the current in coil 1. In like manner good commutation in coil 2 may be brought about by an interpole placed at either *A* or *B*. Similar statements may be made regarding coils 3 and 4. In other words, a commutating pole placed at *B*, if properly magnetized, will take care of commutation in both coil 2 and coil 3, and a similar

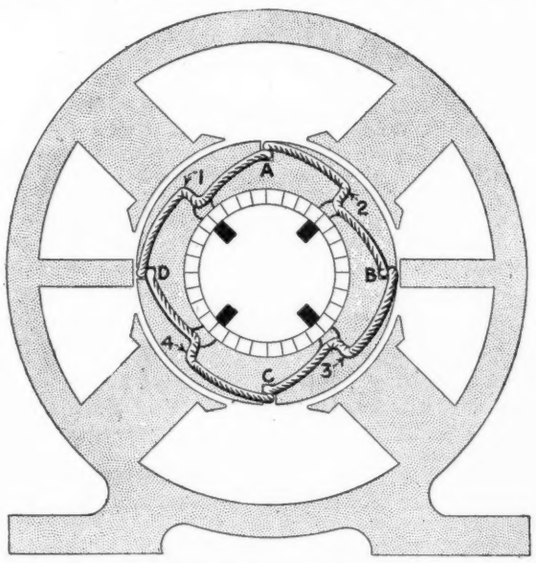


FIG. 9. FIELD FRAME HAVING FOUR MAIN POLES AND TWO INTERPOLES

commutating pole placed at *D* will take care of commutation in coils 1 and 4. It follows, then, that interpoles at *A* and *C* may be dispensed with if those at *B* and *D* are of suitable strength.

In general, in any machine, the number of interpoles may be made either equal to or half of the number of main poles. The usual practice is to use as many interpoles as main poles when the number of pairs of main poles is odd. For example, in a six-pole machine six interpoles and in a two-pole machine two interpoles are used. There is, however, no reason why a six-pole machine with three interpoles or a two-pole machine with only one interpole will not operate as well as a four-pole machine with two interpoles as in Fig. 2, the last arrangement being a very common type of construction. When the number of commutating poles is half the number of main poles, the commutating poles are all of the same polarity; that is, they are either all north or all south poles.

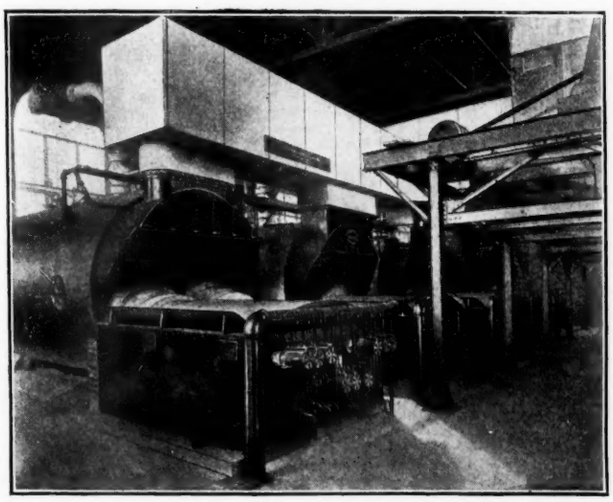
There are certain cases in which a machine should have as many interpoles as main poles. One instance is in three-wire generators, where, for the sake of securing a perfect balance on both sides of the neutral wire, it is required that all the north-pole commutating windings be connected in on one side of the line and all the south-pole windings on the other. Obviously, if the interpoles are all north or all south poles, which, as has already been stated, is the case when there are only half as many of them as there are of main poles, this balanced condition is impossible.

(A subsequent article will explain how interpoles influence the other characteristics of direct-current generators and motors.)

Heating Plant of New State Capitol of Oklahoma

BY J. EARL PULLEN

The steam-heating plant of the new state capitol at Oklahoma City, Okla., contains a number of interesting features, some of which are illustrated in the accompanying view of the boiler room. Five single-ended Scotch marine boilers having a total of 1250 boiler horsepower supply steam to the capitol building, the pipes being run through a 750-ft. tunnel. One of the boilers has two furnace flues and the other four are of the single-flue type, but all are fitted with McMillan dutch-oven furnaces. Gas is used as fuel, each furnace



BOILER ROOM OF OKLAHOMA STATE CAPITOL HEATING PLANT

having nine Gwynn gas burners, arranged in groups of three, as shown. After leaving the boilers the gases pass through a Sturtevant economizer located overhead on a suitable framework. The remainder of the equipment consists of a duplex boiler-feed pump, two vacuum pumps and an air compressor. The plant has been in operation since late in 1918.

A horizontal return-tubular boiler made without a steam dome is generally provided with a dry pipe. This consists of a perforated pipe of large diameter having a length equal to about one-third or one-half the length of the boiler. It is attached to the upper part of the shell on the inside and is connected to the steam pipe leading to the main steam header or to the engine, as would be the case where but one engine is in service.

Care of Heating and Ventilating Equipment—VIII

BY HAROLD L. ALT

In this article vacuum-heating systems are discussed, their operation and care, the troubles to which they are subject, and how these troubles may be avoided and the system kept operating at good efficiency.

THE vacuum system of steam heating so commonly applied to buildings involves drawing back both the condensate and air from the system with a vacuum pump, which discharges the mixture of air, water and vapor into a separating tank. The air and vapor pass off through a vent pipe, while the water may be returned to the boiler. A typical vacuum installation is illustrated in Fig. 1. The chief characteristics of such a system are quick action, graduated heat control at the radiators, small return pipes and its suitability for large installations. It is quite commonly used where exhaust steam is utilized for heating and in groups of buildings where large areas of ground

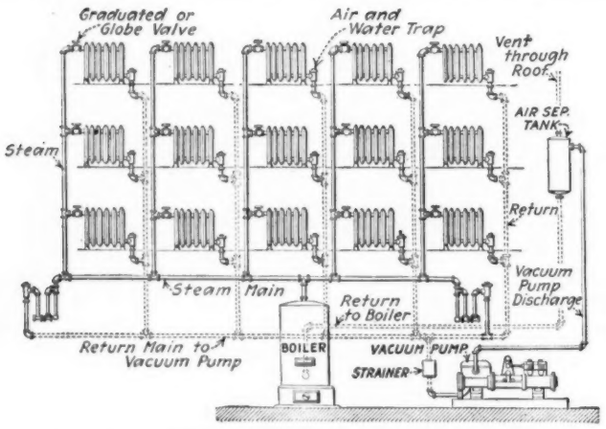


FIG. 1. A TYPICAL VACUUM HEATING SYSTEM

are covered. Steam is supplied to a vacuum system usually under a slight pressure above that of the atmosphere and may run up to 5 or 8 lb. gage and is supplied to the radiators through an ordinary radiator valve or through a valve with a graduated action so that any desired proportion of the radiator surface may be heated.

All types of graduated valves depend upon reducing the size of inlet orifice so that only part of the steam necessary to heat the radiator is admitted in the intermediate positions, and steam or vapor may occupy only a part or all of the radiator. Radiators of the hot-water type, as shown in Fig. 2, are used with the graduated valve set in various positions. The steam or vapor being lighter than the air in the radiator, it seeks the top. To prevent pulling steam down into the return line and breaking the vacuum, traps are placed on the return end. These traps operate on the same principle as radiator air vents already described, passing air and water but not steam. Some traps for this purpose have a small permanent opening to pass a little air or vapor at all times in order to keep the radiator free, but the discharge of steam through this orifice is so small that it is condensed in the return line before getting back to the vacuum pump.

Such traps operate on one of two principles—either thermostatic (expansion) or the float (water-seal) action. The first trap developed for such work was of the expansion type, like the automatic air valve previously described, but it had a very small movement

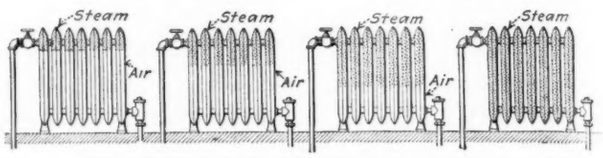


FIG. 2. RADIATORS REPRESENTED PARTLY OR WHOLLY HEATED

so that the outlet was easily clogged and scale or grit lodging on the seat was liable to injure the expanding part by preventing its proper elongation. These troubles proved so objectionable that the water-seal trap was evolved, in which a small float rises and gives a full opening whenever a slug of water comes along and air relief is obtained at all times through the small opening through the valve. Later, other forms of expansion valves were made that are entirely satisfactory.

Little difficulty in operation is encountered with the supply valves, but with the return traps the case is different, for these, operating only by expansion or gravity, are easily troubled by scale or dirt, some of their ills being sticking, water-logging, cracking, etc. This is especially true of the older and more obsolete types, while the more modern designs have to a greater extent minimized these troubles. The vacuum system will operate with more faults in the piping than any other because the vacuum helps the return back past ob-

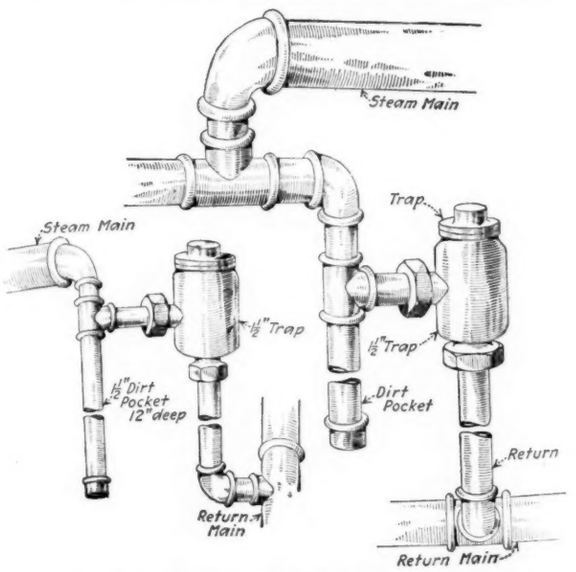


FIG. 3. DIRT POCKETS NEAR TRAPS

structions and through smaller lines than could be used with a gravity system. The thing that must be observed above all others is that no connection can be made between the steam main and the return line except

through a trap. The drip piping from the steam main oftentimes determines whether the system is going to operate satisfactorily or not, and if the main drips do not properly relieve the water, trouble will result. The hard service required of a main drip trap has led some manufacturers to produce a "drip" trap of heavier construction than the return or radiator trap, suitable for

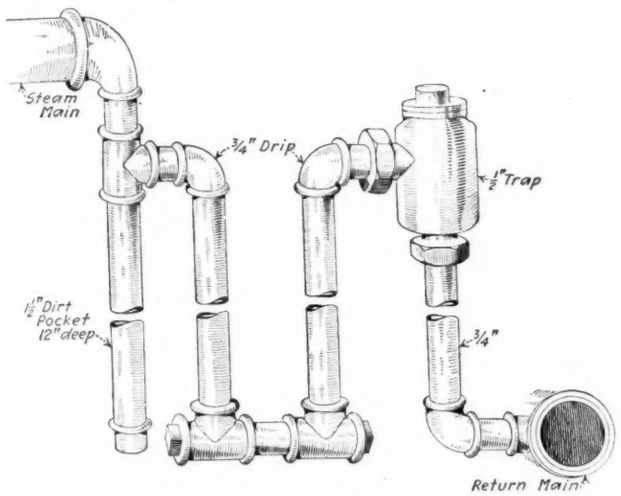


FIG. 4. WATER SEAL IN ADDITION TO DIRT POCKET

hard service. Where a trap is used to drain a header, dirt and sediment should, by all means, be kept out of the trap. This can best be accomplished as shown in Fig. 3 or 4, in which loose particles fall into the dirt pocket made of 1½-in. pipe. If this dirt pocket is made

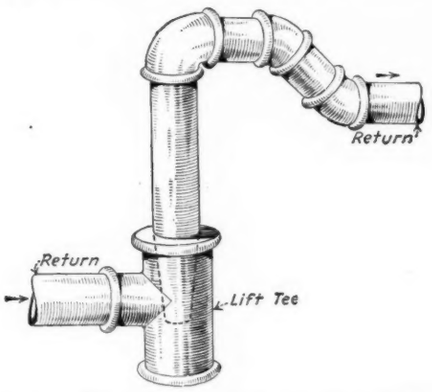


FIG. 5. LIFT FITTING FOR VACUUM SYSTEM

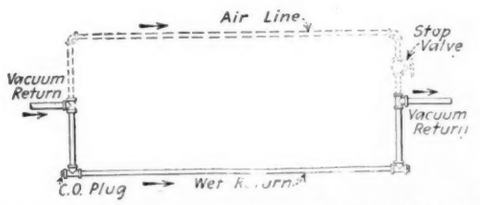


FIG. 6. AIR-LINE METHOD OF PASSING DOORWAYS

12 in. deep, it will probably accommodate all the scale that will ever come along—at least it will serve without attention for many years. Still better results are obtained if a water seal, as shown in Fig. 4, is interposed between the steam main and the trap to protect the expansion mechanism from the destructive slugs of water which sometimes shoot along the main when the steam is first turned on, and it also allows the drip to cool down to a point where the thermostatic member will be in contact with water cold enough to cause it to operate. In fact, one objection to the thermostatic trap is that hot condensation will not cause the trap

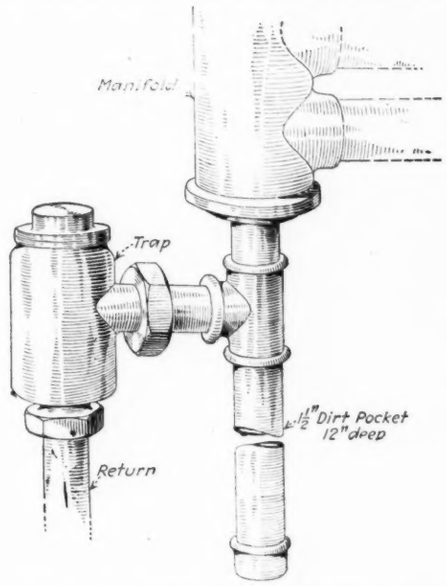


FIG. 7. DRIP CONNECTION FROM A COIL

to open and the water will be held at the trap until it cools. The customary method of piping steam in such systems consists of starting at a high point and pitching down to a point where another rise is desirable or where a drip is necessary, then make the rise in the main and connect a drip at this point, continuing in this manner to the end of the main, where the last drip connection is made in the manner illustrated in Fig. 3 or 4. For best operation drips on the steam main

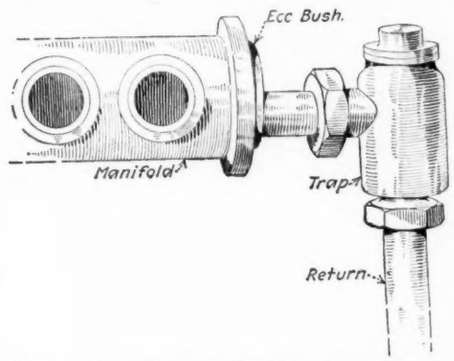


FIG. 8. ECCENTRIC BUSHING IN MANIFOLD

should not be more than 100 ft. apart and on straight mains should be made as shown in Fig. 3.

Owing to the vacuum return handling both air and water, because no automatic air valves are used on the radiators, the return cannot be raised at any point without water sealing and preventing the escape of the air. There are two ways of accomplishing this, one being by means of a lift fitting arranged as shown in Fig. 5 and the other by a water seal in the return line and providing a separate air line to bypass the seal, as shown in Fig. 6. Where returns are carried above the floor, difficulty occurs at doorways, but this may also be solved by the air-line method, as shown in Fig. 6. If it is desired to empty the line of water that

would otherwise be retained, the simple installation of a single valve in the air line as indicated will make it possible to draw all the water out by suction when these valves are closed and the vacuum pump run a short time at the end of the season.

Where leaky traps are giving trouble by vapor getting into the steam line, a remedy of more or less permanent nature will be found in connecting a small cold-water line to the vacuum return close to the vacuum pump. This line is sometimes connected to the pump strainer (which should always be used) and is used to supply a small quantity of makeup water at all times, while others use a special cast-iron condensing chamber or surface condenser in which the uncondensed vapor is brought into contact with the cold-water tubes, resulting in an almost perfect vacuum. The cold water supplying the house service, heaters or boiler-feed line is carried through these tubes in series and keeps them cool. In order to keep the system operating at a good

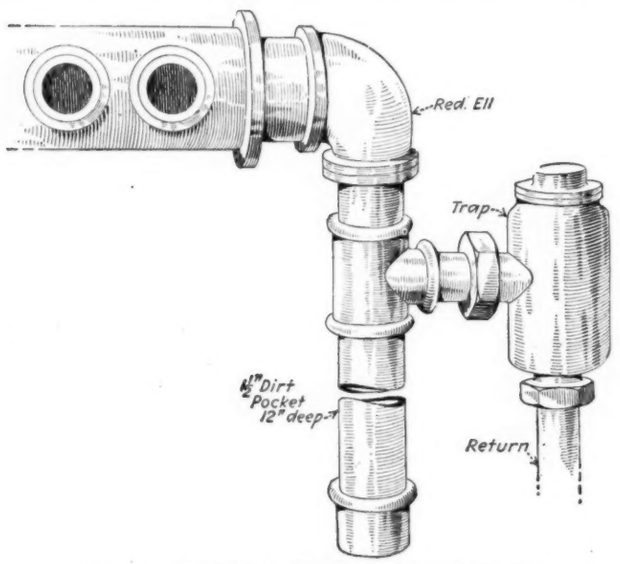


FIG. 9. REDUCING ELBOW FOR DRAINAGE

efficiency, the pump strainer should be cleaned frequently, the periods of cleaning being more frequent in new systems and decreasing as the system becomes gradually more and more cleaned out.

Pipe coils are not treated quite the same as radiators in the matter of connecting traps. While on the radiators no strainers or dirt pockets are used, these are recommended on large pipe coils, being placed between the coil and the trap with the strainer arranged so that the particles will fall into the wire basket, which may be easily removed and emptied. On wall coils the bottom of the manifold is commonly bushed to 1½-in. pipe and the regular drip connection made as shown in Fig. 7; but if the coil lies horizontally, as is the case with ceiling coils, the return connection can be made by the use of an eccentric bushing (Fig. 8) or, better still, with a reducing ell and regular connection (Fig. 9). Where steam mains lie below the return lines or where the drip connections throw the trap outlet below the level of the return line, it is perfectly permissible to lift the trap discharge for a small distance (say not to exceed three feet) as shown in Fig. 10; because a trap in such a location does not necessarily handle air. In handling water alone the water sealing of the trap discharge by lifting it to a higher level is not objectionable provided there is ample opportunity for the air to escape elsewhere. Of course, if such a connection is to be used when air must be considered, a regular lift fitting must be used.

In a case where more than one building is connected to a system, it is sometimes desirable to place a vacuum

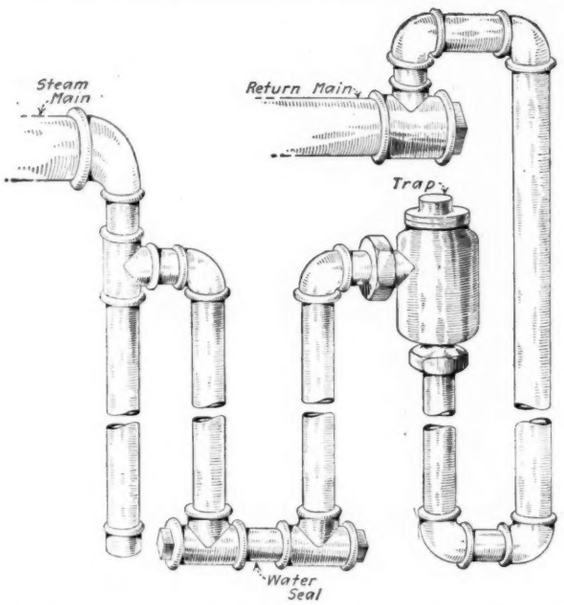


FIG. 10. POSSIBLE CONNECTION IF NO AIR IS PRESENT

regulator on each building so that any desired vacuum can be carried on any building, and a building with sluggish circulation can be helped out by increasing its vacuum slightly. This is accomplished by employing a trap that passes the water of condensation as fast as it is produced, but has a diaphragm control on the air-

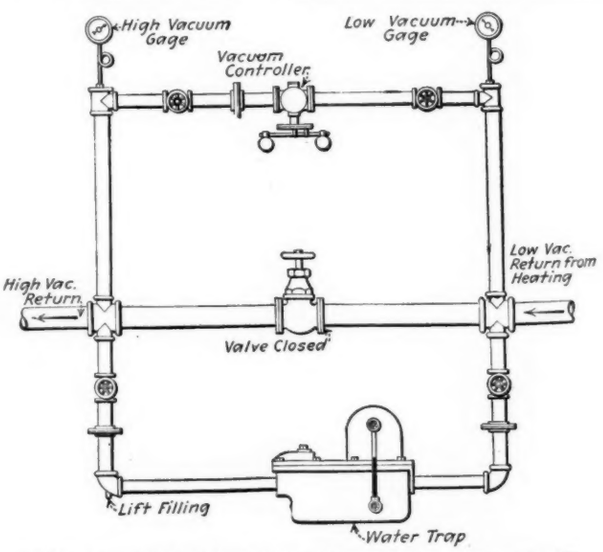


FIG. 11. ARRANGED FOR DIFFERENT DEGREE OF VACUUM

line bypass around the trap, so that any desired degree of vacuum can be placed on any building as desired. The connections around such a trap are illustrated in Fig. 11 and are self-explanatory. Of course, the vacuum on the main line must equal or exceed the highest vacuum expected to be maintained in any building.

Statistical Analysis of the Central Electric Stations of Canada

Figures showing the various kinds and amounts of power in Canadian central electric stations, capital invested and salaries and wages paid, with data of especial interest concerning hydro-electric power.

GROWTH of the central-station industry in Canada has been rapid, particularly during recent years. The larger electric systems, both commercial and publicly owned, have been widely extended from year to year, opening up new territory in the electrical-distribution field.

To measure properly the scope of the industry and to gage its importance to commercial and industrial interests, the Dominion Water Power Branch of the Department of the Interior, in coöperation with the Dominion Bureau of Statistics of the Department of Trade and Commerce, has had under way during the past year an exhaustive analysis of the central electric stations of the Dominion. As some time must elapse before the complete report can be published and distributed, a brief synopsis of the statistical data has been prepared.

In considering the statistics that are summarized hereunder, it should be borne in mind that the figures have reference solely to central electric stations; that is, to stations engaged in the distribution and sale of electrical energy. Where central stations were interwoven with other activities, such as the operation of electric railways, mines, pulp mills or other industrial enterprises, the central-station equipment, capitalization and other statistical data secured have been wholly divorced from the allied industry. This line of severance has been drawn through the entire statistical analysis. Central stations purchasing power in bulk for purposes of resale are included in the financial and staff statistics.

The total number of central electric stations recorded is 666, of which 323 are commercial stations and 343 are municipal. Examination of the figures, however, shows that the excess in municipal stations is attributable to the nongenerating station. Of the stations with generating equipment 296 are commercial and 174 are municipal. Of the stations without generating equipment 27 are commercial stations and 169 are municipal. The hydro-electric power system of Ontario is largely responsible for the large proportion of municipal stations purchasing power in bulk.

Table I summarizes by provinces the number, kind and horsepower of the primary power machines installed in central electric stations on Jan. 1, 1918. The primary power totals 1,844,571 hp., of which 78.3 per cent., or 1,444,314 hp., is installed in commercial stations and 21.7 per cent., or 400,257 hp., in municipal stations. Of the total primary horsepower installed 1,652,661 hp. is derived from water, 180,200 from steam and 11,710 from gas and oil. From these figures it will be noted that 89.6 per cent. of the entire primary power in central stations in Canada is derived from water.

One of the most important features of the statistics in Table I is the outstanding position which water power takes in the central-station field. Out of a total installed primary capacity of 1,844,571 hp., 1,652,661, or practically 90 per cent., is derived from water. This figure is indicative of the extent and availability of the water-power resources of the Dominion and of the remarkable degree to which their adaptability for central electric station work has been appreciated in principle and realized in practice. The vast water-power resources of the Dominion, the ready adaptability of hydro power to the production of electrical energy and the increasing extent and scope of economical electrical transmission, form an industrial asset which probably more than any other will insure a full measure of future prosperity.

TABLE I. NUMBER, KIND AND HORSEPOWER OF PRIMARY POWER MACHINES, 1917

	Total Primary Power			Kind of Power																	
				Total Steam			Steam Engines			Steam Turbines			Gas and Oil Engines			Water Wheels and Turbines			Total Primary Power		
	Horsepower		Per Cent. of	Horsepower		Per Cent. of	Horsepower		Per Cent. of	Horsepower		Per Cent. of	Horsepower		Per Cent. of	Horsepower		Per Cent. of			
	No.	Total	Total	No.	Total	Total	No.	Total	Total	No.	Total	Total	No.	Total	Total	No.	Total	Total	Commercial Stations	Municipal Stations	
Canada	983	1,844,571	100	251	180,200	9.8	207	53,312	2.9	44	126,888	6.9	113	11,710	0.6	619	1,652,661	89.6	1,444,314	400,257	
Alberta	82	75,417	4.1	57	41,862	55.5	47	12,162	16.2	10	29,760	39.3	11	975	1.3	14	32,580	43.2	49,312	26,105	
British Columbia	86	232,648	12.6	22	21,808	9.4	16	3,308	1.4	6	18,500	8.0	12	1,815	0.8	52	209,025	89.8	219,990	12,658	
Manitoba	41	67,337	3.6	15	2,575	3.8	15	2,575	3.8				11	662	1.0	15	64,100	95.2	24,888	42,449	
New Brunswick	40	17,733	1.0	20	9,790	55.2	17	5,890	33.2	3	3,900	22.0	5	1,065	6.0	15	6,878	38.8	15,488	2,245	
Nova Scotia	55	17,444	0.9	39	13,950	80.0	36	7,830	44.9	3	6,120	35.1	2	140	0.8	14	3,354	19.2	13,855	3,589	
Ontario	352	784,665	42.5	43	31,745	4.0	37	8,845	1.1	6	22,900	2.9	11	1,917	0.3	298	751,003	95.7	521,396	263,269	
Prince Ed. Isl	10	1,226	0.1	2	425	34.7	2	425	34.7				3	631	51.4	5	170	13.9	1,226		
Quebec	232	606,082	32.9	22	30,245	5.0	16	4,745	0.8	6	25,500	4.2	6	286	0.1	204	575,551	94.9	586,851	19,231	
Saskatchewan	81	31,759	1.7	29	27,540	86.8	20	7,472	23.5	9	20,068	63.3	52	4,219	13.2				1,048	30,711	
Yukon	4	10,260	0.6	2	260	2.6	1	60	0.6	1	200	2.0				2	10,000	97.4	10,260		

Table II presents the principal features of the statistics respecting employees, salaries and wages. For the entire Dominion the number of employees in central electric stations totals 8847, with salaries and wages aggregating $7,777,715. Of this total 5135 are employed in commercial stations with salaries aggregating $4,290,505, and 3712 in municipal stations with salaries totaling $3,487,210. The total number of employees throughout the Dominion averages 4.8 per thousand installed primary horsepower. The total salaries and wages paid average $4.22 per annum per installed primary horsepower. Reference to the salaries and wages per installed power capacity discloses the fact that those provinces in which are located extensive transmission systems of large central-station systems, show a low salary and wages bill per installed horsepower capacity. These extensive systems are in all cases founded upon water-power installation. On the other

hand in those provinces where central-station industry is wholly or largely confined to individual stations for local purposes, the unit salaries and wages cost per installed capacity is high.

A few of the outstanding financial features of the industry are set out in Table III. The capital actually invested in central electric-station industry totals $356,004,168, of which 79.5 per cent. is invested in commercial stations and 20.5 per cent. in municipal or publicly owned stations.

The capital indirectly dependent upon electrical energy is enormous. No attempt has been made to go into this phase in this report. As showing the general dependability of the modern community upon electrical energy, reference might be made to the City of Winnipeg. According to a very careful and complete analysis made by the Dominion Water Power Branch in 1915 of the interests in Winnipeg which were to a greater or less degree dependent upon hydro-electric power derived from the Winnipeg River, it was shown that capital was involved to the extent of $169,260,963, and this on a power installation of only 55,400 hp. The total revenue received from the sale of electrical energy in 1917 was $44,536,848, of which $27,135,399 was secured by commercial and $15,401,449 by municipal plants.

In securing the statistics concerning capital, the actual cash investment in the central-station activities was called for, apart from the consideration of stock and bond issues. The resulting figures are therefore of particular interest as a basis for determining the investment cost per horsepower installed. The figures indicate that the actual average cost per installed horsepower for the Dominion is $193. This cost includes all capital invested in construction and equipment of hydraulic works, power stations, transmission and distribution systems; real estate; cash on hand; current assets; supplies, and all other similar items.

Of special interest are the figures relating to the capital invested in hydro-power central stations. The average capital cost per installed horsepower for the Dominion is $188. Referring to the table, the investment per turbine horsepower in Alberta appears remarkably low. This is partly explained by the fact that in the analysis the distribution system in the City of Calgary is not charged to the hydraulic developments serving the city.

Of special interest is the actual cost of construction of hydro-electric power stations per installed horsepower. Omitting all real estate, transmission and distribution equipment, seventy representative hydro-electric stations throughout the Dominion with an aggregate turbine installation of 745,797 hp. and a total construction cost of $50,740,468 show an average cost of $69.11 per installed turbine horsepower. The figure in brief represents the average capital cost of construction at the power site and is of considerable interest to engineers.

A comparison of the central-station statistics of Canada with similar figures in the United States would be of interest. Unfortunately, the 1917 census returns of the United States will not be ready for publication for several months. While it is scarcely fair to compare the 1917 returns with the 1912 returns of the United States, the figures may be instructive. The proportion of central-station power derived from water in Canada is practically 90 per cent. In the United States in 1912 the hydro-power portion was 30 per cent. of the total. The water power used in central-station work in Canada averages 198 installed horsepower per thousand population. In the United States in 1912 the similar figure was 24.7 hp. per thousand population.

While the ratios in the United States have undoubtedly very materially increased during the past five years, there is little doubt that the ratios for the Dominion are substantially in advance of those in the United States. The fundamental reason underlying the great use of water power in central-station work in Canada lies in the fact that with but two or three exceptions, every city of importance in Canada is served with central-station power from hydro-power stations. In other words, practically all the commercial and industrial centers of the Dominion are within easy transmission distance of ample supplies of economically developed hydro-electric power.

TABLE II. TOTAL NUMBER OF EMPLOYEES, AND SALARIES AND WAGES PER PRIMARY HORSEPOWER INSTALLED

Division	Total Primary Horsepower Installed	Salaried Employees and Wage-Earners		Salaries and Wages		Commercial Stations		Municipal Stations	
		Total Number	Per 1000 Hp. Installed	Total	Per Hp. Installed	Total Employees	Total Salaries and Wages	Total Employees	Total Salaries and Wages
Canada	1,844,571	8,847	4.8	$7,777,715	$4.22	5,135	$4,290,505	3,712	$3,487,210
Alberta	75,417	438	5.8	458,423	6.08	156	152,652	282	305,771
British Columbia	232,648	453	2.0	496,081	2.13	310	357,488	143	138,593
Manitoba	67,337	405	6.0	433,262	6.44	79	66,669	326	366,593
New Brunswick	17,733	215	12.1	155,164	8.75	178	125,945	37	29,219
Nova Scotia	17,444	288	16.5	227,874	13.07	235	193,314	53	34,560
Ontario	784,665	4,147	5.3	4,063,060	5.18	1,777	1,920,659	2,370	2,142,401
Prince Edward Island	1,226	23	18.8	17,402	14.19	23	17,402	.....	.....
Quebec	606,082	2,476	4.1	1,514,186	2.50	2,301	1,361,153	175	153,033
Saskatchewan	31,759	363	11.4	348,952	10.98	37	31,912	326	317,040
Yukon	10,260	39	3.8	63,311	6.17	39	63,311	.....	.....

TABLE III. CAPITAL INVESTED IN CENTRAL STATION INDUSTRY AND IN HYDRO POWER CENTRAL STATIONS

	In All Central Electric Stations					In Hydropower Central Electric Stations		
	Total Primary Horsepower	Total Capital Invested			Total in Municipal Stations	Total Turbine Horsepower	Total Capital Invested	
		Amount	Per Primary Horsepower	Total in Commercial Stations			Amount	Per Turbine Horsepower
Canada	1,844,571	$356,004,168	$193	$282,818,495	$73,185,673	1,652,661	$310,104,658	$188
Alberta	75,417	11,102,620	147	5,634,479	5,468,141	32,580	2,293,537	70
British Columbia	232,648	43,548,492	187	41,255,719	2,292,773	209,025	41,045,100	196
Manitoba	67,337	12,078,173	179	3,460,220	8,617,953	64,100	11,493,274	179
New Brunswick	17,733	3,443,848	194	2,941,569	502,279	6,878	1,315,723	191
Nova Scotia	17,444	3,376,405	194	2,776,101	600,304	3,354	686,705	205
Ontario	784,665	142,777,379	182	96,538,585	46,238,794	751,003	129,342,065	172
Prince Edward Island	1,226	211,900	173	211,900	.....	170	48,400	285
Quebec	606,082	130,213,470	215	126,080,992	4,132,478	575,551	120,516,166	209
Saskatchewan	31,759	5,590,515	176	257,564	5,332,951	.....	.....	.....
Yukon	10,260	3,661,366	357	3,661,366	.....	10,000	3,363,688	336

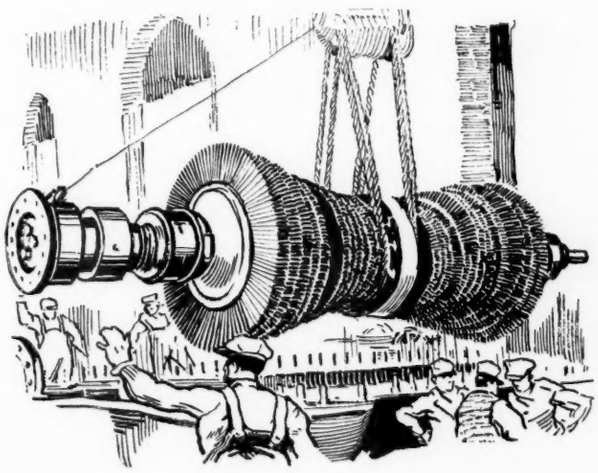
ITALY UTILIZES VOLCANIC POWER

THE enormous price of coal in Italy has resulted in the realization of an idea which at first thought seemed visionary, but which has been developed in a marvelous manner and is assuming considerable importance; this is the industrial exploitation of the natural heat emitted from the soil in those regions more or less volcanic in character.

The first experiments along this line were made some years before the war by Prince Ginori-Conti, in Tuscany, at Larderello, near the salt mines of Volterra, a region extensively covered with volcanic formations, the most wonderful being the so-called "soffioni," which are certain volcanic vents emitting powerful jets of very hot steam containing boric salts and various gases used in the extraction of boracic acid. Instead of limiting the use of these steam jets, as in the past, to extracting the salts contained in the exhalations of these natural

vapor vents, the ejection of the steam is stimulated by boring holes. In this way it is possible to obtain powerful jets at a pressure of two to three atmospheres, according to the locality, and in some exceptional instances as high as five atmospheres, the temperatures varying from 150 to 165 deg. C. These jets maintain their force and temperature unchanged for many years, and they are not affected even when other openings, not too near each other, are bored in the ground, proving that they do not influence each other reciprocally, so great is the underlying thermic energy. In 1905 Prince Ginori-Conti applied this natural steam to a 40-hp. engine, using only a small section of the Nenella fissure, which is the most powerful "soffione," the steam ejected having a pressure of five atmospheres. The results obtained during several years of experimentation were satisfactory, so that he continued to make larger and deeper borings, measuring the force of the steam ejected; combined, this force could operate engines of many thousand horsepower. In 1912 an experiment was made, very wisely on a more modest scale, but sufficient to obtain conclusive results, for which a 300-hp. turbine-alternator was used.

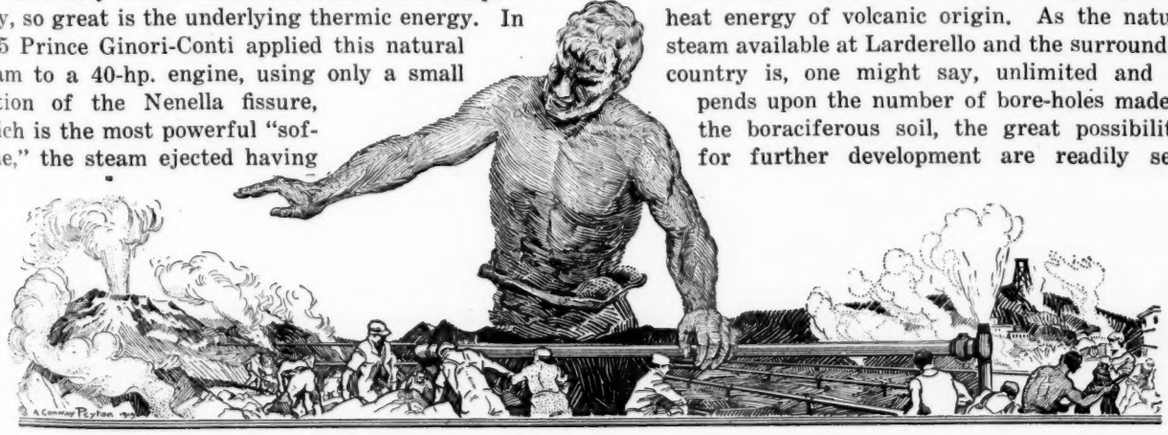
Later, because of the enormous increase in the price of coal, the Prince decided to exploit the thermic energy of these "soffioni" on a much larger scale. But as other



substances are emitted with the steam, among them sulphuric acid, which corrodes metals, particularly iron and therefore the pipes in which the steam was to be collected, he attempted to use this steam only for heating. Three turbine-alternators of 3000 kw. each were installed, fed by boilers at low pressure not heated by coal or other combustible fuel, but by the natural steam, superheated to 165 deg. C., issuing from these "soffioni" and piped and carried to the boilers.

Today the works at Larderello have a central plant of 16,000 hp., operating without interruption and distributing current to Florence, Livorno and Grosseto; the capacity is soon to be increased.

Here we have a new and original utilization of Italy's natural wealth; current is generated, not by the use of "white coal" (water power), but by means of heat energy of volcanic origin. As the natural steam available at Larderello and the surrounding country is, one might say, unlimited and depends upon the number of bore-holes made in the boraciferous soil, the great possibilities for further development are readily seen.



Why Should the Work of the Fuel Administration Cease?

By GEORGE H. SHEASLEY

WASHINGTON, Feb. 1.—The Fuel Administration today discontinued all price control and much of the supervision over distribution of coal, coke, oil and natural gas under an order signed by Administrator Garfield. With the passing of control over fuel, most of the activities of the Fuel Administration ceased. The Administration, however, under the Lever Act, cannot disband until peace has been declared. Some coal men said today that cessation of control over prices on coal would result in a lowering of prices. The unusually mild winter, it was said, also would tend to lower prices. Others predicted little change in price levels.

The press dispatch here quoted has a significant meaning.

The Fuel Administration is passing. Its much-criticized activities will, in all probability, soon have their existence in history only. Like many other war measures, the control of fuel ceases in the wake of the passing calamity which was the means of bringing it about. As indicated, the Fuel Administration must theoretically remain in existence under the Lever Act until peace is actually established. However, with the cessation of price control and the bulk of distribution supervision it is plain that the need for this branch of Government activity is past or rapidly passing and that its existence until the declaration of peace will be little felt by either the producer or the consumer of coal.

Control of Prices Has Benefited the Consumer

The Fuel Administration, through its control of prices, undoubtedly has been the means of saving the consumer much money by preventing an abnormal jump in price which otherwise would have been almost certain to accompany the coal crisis during the winter 1917-18, and the more or less inadequate supply of the last year. By direct pressure brought to bear upon the consumer through the control of distribution and an educational campaign directed toward conservation, it has also been the means of saving enormous quantities of coal that would otherwise have been carelessly wasted, even in the face of the existing shortage. On the other hand, the Fuel Administration, hastily organized and handicapped by urgency of action in order to meet the emergency, undoubtedly has made mistakes that in some instances may have caused hardships that might have been avoided. In return for this it has probably been the object of more severe criticism than any other governmental department. But what man or group of men ever became associated with the initial attempt to remedy a serious situation, and actually remedied it, without making some mistakes, stepping on a number of uncovered or very thinly clad toes and receiving the usual amount of criticism as an additional reward for their efforts? The chief trouble with the average critic is that he does not see the true situation at all and, in turn, views the remedy applied only as it affects him individually, whereas the reformer must observe the situation in a collective light and adopt the desired remedy on the same basis.

Regardless of judgment that has been or may be passed on the efforts of the Fuel Administration, the fact remains that, in spite of possible mistakes, the carrying out of its conservation program has been the means of bringing about a huge fuel saving. The significant thing about the passing of the major portion of its activities is the indication that the fuel situation is rapidly approaching its normal condition. Its relinquishing control of prices is evidence that with the lull in industrial activity, the rapid improvement in transportation facilities and the effect of an unusually mild winter, a shortage no longer exists. Consequently, the law of supply and demand will now be able to take care of any desire on the part of the producer to boost selling prices and will probably cause their lowering before long.

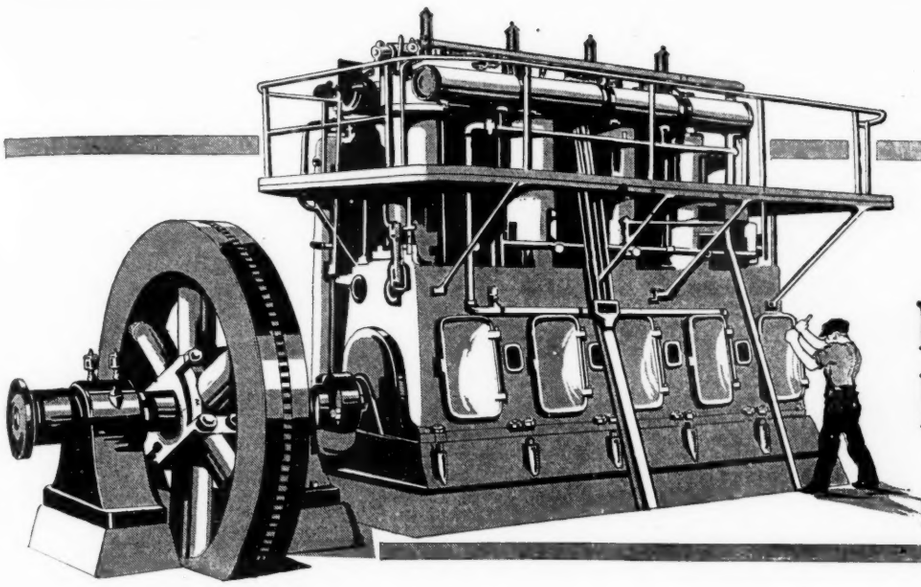
On the other hand, and for the same reason, the discontinuing of supervision over distribution indicates that there is no longer a necessity for restriction and compulsory conservation. Therefore the consumer, after having been protected from the producer and from himself as well for considerably over a year, is once more the sole master of his own coal pile and the manner in which it is used.

With the element of compulsion removed and the fuel situation further tempered by a gradual decline in price which is certain to accompany the return of normal market and transportation conditions, what will be the attitude of the industrial and the domestic consumer, but particularly the industrial consumer, toward the matter of conservation? The estimates of the Fuel Administration indicate that by the careful carrying out of its wartime conservation measures, a saving of one hundred million tons of coal per year is by no means a remote possibility. Thus the logical conclusion must be that under pre-war conditions this amount of coal was annually wasted, and a large portion of the waste is chargeable to industry.

Conservation or Waste a Matter of Personal Choice

Conservation or waste was a matter of choice with the consumer. Little action was taken toward the former and the latter was the result. The necessary steps for the forcible prevention of waste by the Government during peace may be unconstitutional, but the argument that this is the consumer's personal problem is unreasonable. The wasting of coal is not a personal matter, but the impoverishing of a national resource, and in industry the huge sums of money thus involved find their direct reflection in the price of the finished product. Therefore the matter of fuel waste is a national problem in peace no less than in war.

This being the case, why the cessation of this branch of Government control? If necessary during war—and no one will doubt that it was—the result accomplished will indicate that it is at least desirable during peace. Therefore, why not the adoption of necessary legislation to make the Fuel Administration, or a similar organization, a permanent governmental department?



Talks on DIESEL Engines

by L. H. Morrison

IX—The construction of inlet and exhaust valves and their cages serves to occupy the minds of the men during an entire evening's talk.

"NOW, boys," began Egan when they had gathered for their next talk, "the exhaust and inlet valves are pretty closely associated with cylinder heads, so we'll consider valves next. I've found that Woods here is a fair draftsman and he's going to give us sketches of the valves we'll talk about." He turned to the young fellow, who stood at his elbow flushing self-consciously. "Let's begin with your Fig. 1," he said, and Woods sorted out the sheet and handed it to him. "This drawing," said J. R., "shows the inlet valve and cage of the original American Diesel. The valve is mounted on an extension at one side of the cylinder head, and the joint at *A* between the cage and the head is made tight by a copper gasket. Special attention should be given to this gasket. Quite a number of engines use copper gaskets on the valve cages, and they're a source of trouble. The average engineer is careless about getting the correct size—the gasket usually is cut too large on the outside. When the cage is inserted into the head cavity, the gasket binds, it's impossible to draw the bolts up snug, and as a consequence leaks occur around the cage. It's a good plan to always cut the copper gasket $\frac{1}{16}$ in. smaller, outside diameter, than the seat on which it to rest.

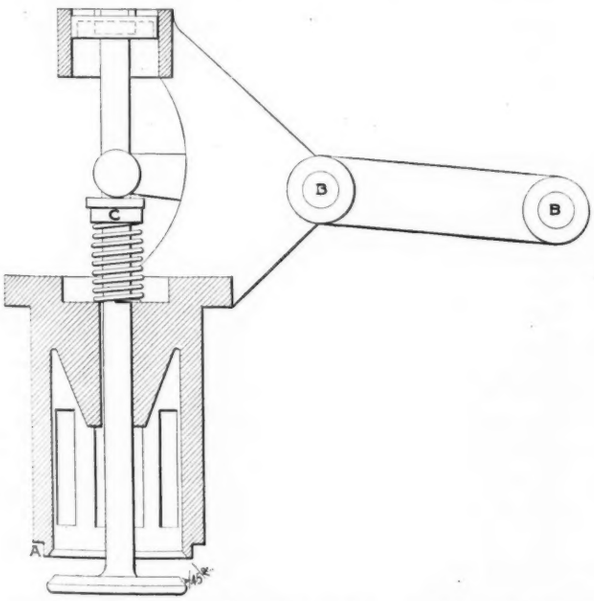


FIG. 1. INLET VALVE AND CAGE OF AMERICAN DIESEL ENGINE

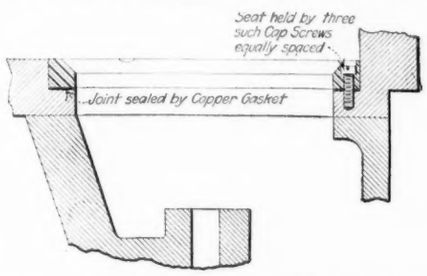


FIG. 2. FALSE SEAT FOR EXHAUST VALVE

"In some of the other plants the chiefs purchase gaskets from the engine builder. Of course in this way they are always sure of getting the correct size, but usually the price paid is quite out of proportion to this advantage. Here at the plant we originally made all the gaskets out of sheet copper, cutting them as required. In making a gasket as large as a valve-cage gasket we always kept the center cut out instead of throwing it away. We found that ordinarily a couple of small gaskets could be cut from this waste stock. This served to keep down our gasket expense. The last two or three years we have inclined toward the exclusive use of copper wire for valve-cage gaskets as well as cylinder-head gaskets. These are bent around a wooden form and the two ends are soldered together with a

At the next meeting Egan will explain how to determine when a valve needs regrinding, how to perform that operation and how to time the action of the inlet and exhaust valves

very soft solder. This is one of my own pet ideas, and for that reason I may be unduly partial, but it's my candid opinion that these wire gaskets are superior to any other.

"Adjustments are the things an engineer is mighty interested in. With a cage of this type the wear occurs on the pins *B* and the admission spring nut *C*. If the pins wear flat all that is necessary is to ream out the holes to a larger size and turn up new pins. This should not be required oftener than once in five years. The valve nut is a bad customer. The movement of the lever in opening the valve causes the threads on the nut to gradually shear off It's an expensive job to secure a new valve and nut; the cheapest method is to drill a ¼-in. hole through the valve stem and the nut. By inserting a bolt with a drive fit, the nut can be locked firmly in place. I've tried spotting the stem and using a setscrew in the nut, but the hammer blow of the lever soon loosens the setscrew.

"The valve and the stem are made in one piece, of steel, and the valve seat is at a 45-degree angle. Frequently the valve stem wears out while the valve itself is in good condition. I've often cut off the stem and welded a new one on the valve."

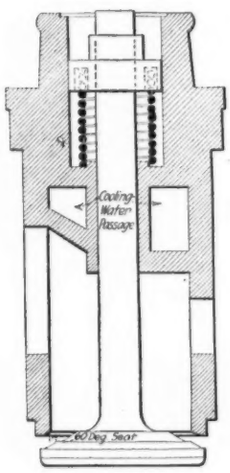


FIG. 3

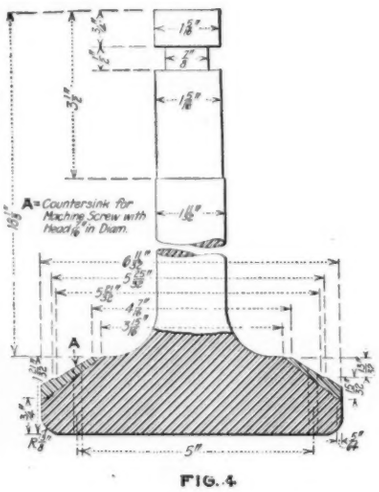


FIG. 4

FIGS. 3 AND 4. VALVE OF McINTOSH AND SEYMOUR ENGINE

Fig. 3—Exhaust valve and cage. Fig. 4—Details of valve

"Chief, why doesn't the exhaust valve have a cage, too?" asked Woods.

"That, I presume, is merely a matter of choice on the part of the designer. Quite a number of engine builders use an elaborate inlet-valve cage, but, when they get to the exhaust valve, seem to be content with making the seat on the cast-iron head itself. If there is any advantage in an inlet cage, then surely the exhaust valve needs it all the more. The hot gases pass over the exhaust-valve seat, and it is natural that it corrodes faster than the inlet-valve seat. It requires grinding oftener, and, if the engine is old, the seat generally has been reamed so often as to make it worthless. We find false seats inserted just as in the case of our old American."

"How can you insert a false seat?" one of the men wanted to know.

"The next time you look into the engine, observe the way we did it. However, this sketch, Fig. 2, will show how it is done. It is necessary to bore out the seat and leave a square-shouldered recess. Then turn up your new seat out of tool steel and drill for three filister-head screws, as I show. You'll find it a job to tap the screw holes in the head, but it can be done if you are careful. When putting in this seat, always use a thin copper gasket to seal the joint. If a better job is desired, you can use an oxyacetylene flame and build up a new seat. This seat, after being reamed and ground, is just as good as the original. Both of these methods can be used on any engine where no exhaust-valve cage is used.

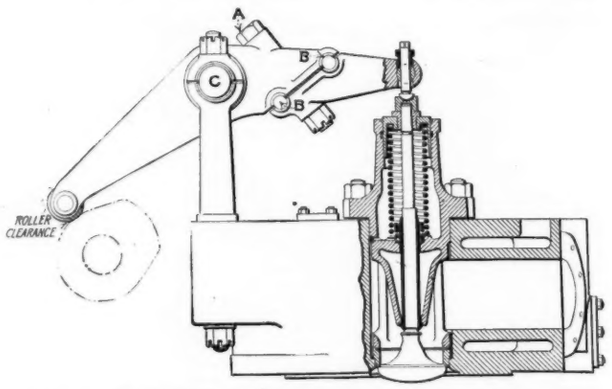


FIG. 5. EXHAUST VALVE OF BUSCH-SULZER ENGINE

"Let us go on to Woods's next drawing, Fig. 3, which shows the exhaust valve and cage used on the McIntosh & Seymour vertical engine. You will notice that the cage is partly water-cooled. While the inlet-valve cage is not so cooled, its dimensions are the same, and the two are interchangeable. In fact, at one of our plants water cooling is cut out, and the cages are used with either valve. In this way only one spare cage need be carried on hand. This cage is sealed by a gasket and is about as neat a design as I've met with.

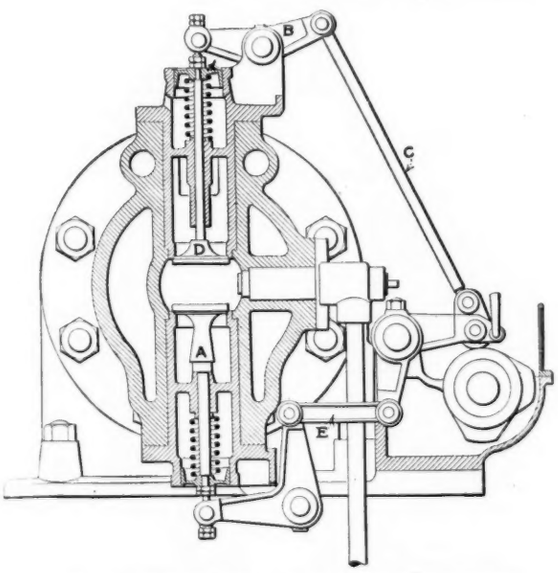


FIG. 6. VALVE GEAR OF McEWEN ENGINE

"Now the exhaust and inlet valves are identical in all respects save one. This difference is the valve seat, which, in the exhaust valve, is a separate part, as Fig. 4 shows. The inlet valve, on the contrary, is in one piece.

The seat on the exhaust valve is a steel shell fastened to the valve body by two countersunk machine screws. As you know, the hot exhaust gases pit the seat and I'll wager we regrind the exhaust valve three times to one regrinding of the inlet valve. With this design, when the seat is badly worn, all we need to do is to replace it."

"J. R., why are the valve seats at a different angle from the other engines here?" Woods inquired.

"The valve-seat angle on these engines is 60 deg. while on the Busch-Sulzer and the American the angle is 45

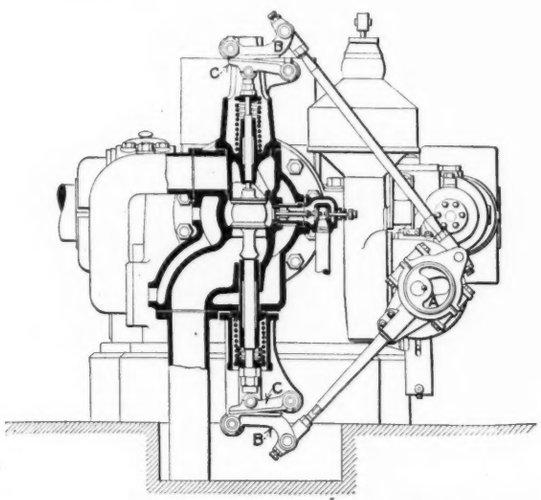


FIG. 7. VALVE GEAR OF ALLIS-CHALMERS ENGINE

deg. This is merely a matter of designer's fancy, and as far as I can see, the angle does not affect the tightness of the valve. I believe it's easier to regrind the 45-deg. seat, but I'll confess this probably is merely a hobby of mine without foundation in fact."

Woods broke in: "Mr. Egan, this cage is like the Busch-Sulzer."

"Yes, it's very much like the Busch; so much so that it was hardly necessary for you to show the latter, as you have done in your Fig. 5. There are four studs holding the cage on the Busch while the other has two lugs. With two lugs it is easier to pull the cage to a perfect seat in the head—at least I have found it so. There is also a difference in the designs of the valve rocker-arms. The McIntosh & Seymour arm is made solid, but the Busch-Sulzer is in two pieces that are held together by a bolt *A*. To make the parts come together in their correct positions, the builders use two dowel pins *B* that rest in reamed recesses at the joint."

"Chief, what's the idea of the arm being made in two pieces?" Kelly asked. "It surely isn't due to trouble in casting the arm."

"The idea is to allow the cage to be removed without removing the whole rocker-arm. You see, since the rocker-arms are mounted on a common shaft *C*, it's necessary to remove the whole rocker assembly to get at a single cage. With the split rocker, only that particular rocker need be unbolted. It is an advantage, and we have never had any trouble in putting the halves together.

"Now, coming to horizontal engines, Fig. 6 shows a cross-section through the valve cages of the McEwen engine. The valves are made separate from the stems, and the exhaust valve has a skirt *A* carried down along the stem to deflect the exhaust gases and protect the stem against being burned out. The rocker-arm *B* is fulcrumed on a bracket cast with the valve cage. The reach rod *C* is fairly long and is in compression when the inlet valve *D* is being opened. On the other hand, the exhaust rod *E* is in tension."

He picked up the sketch shown in Fig. 7 and smoothed it out on the table.

"This is a section of the Allis-Chalmers engine," he explained. "The valves are moved by eccentrics *A* instead of cams, as in the preceding cases. To get a quick opening of the valves, the lever *B* is made with a cam surface that rolls against the face of the swinging tappet *C* that rests against the valve stem. The advantage is that there is no sharp blow when the valve is opened, such as you'd get with a cam striking a roller. The disadvantage is that there are more parts."

"How about grinding valves?" inquired Sandy the Scot, rolling his r's.

Egan glanced at his watch before he replied to the question.

"It's too late to begin that," he said, "for it's a long story. We'll continue it in our next, as the magazines say."

Testing Power Equipment

In a case lately before the District of Columbia Supreme Court (47 Appeal Cases, 147), a suit involving the right of a buyer of soot blowers, used in cleaning boiler tubes, to rescind the purchase on the ground that the equipment failed to do the work it was intended to do, that court laid down the following rules governing cases of this kind:

When machinery is bought on condition that, if at the expiration of a specified test period it proves to be unsatisfactory, it is to be returned at the seller's expense, the buyer is bound for the price unless he gives the machinery a fair test. But he is not bound to continue the test the full period if in a shorter time the machinery is found to be unsatisfactory.

A test period of this character runs from the time that the equipment is properly placed in position to do the intended work.

Where no time is fixed for the return of goods sold subject to the satisfaction of the buyer, they must be returned, or an offer be made to return them, within a reasonable time. A request by the buyer for shipping instructions is sufficient as an offer to return.

Generally speaking, an engine with small clearance space is supposed to be more economical than one with large clearance. It is not so much the clearance space as it is, the clearance surface that affects the economy. If there is a large amount of cooling surface for the steam to come in contact with when it enters the cylinders, there will be a great deal of condensation and more steam will be required. If the valves are placed close to the head of the cylinder, as in the Corliss engine, reducing the surface of the ports and passages and leaving only the cylinder heads and piston and a small section of the cylinder walls to condense the steam, a high degree of economy should be effected.

Calculation of Plant Efficiencies and Fuel Costs

By J. T. FOSTER

Engineering Department, Public Service Electric Co., Newark, N. J.

The author presents two charts with which the engineer may readily determine the efficiency of the boilers, evaporation, and fuel cost per thousand pounds of steam or mills per kilowatt-hour. The charts are worth adding to one's loose-leaf notebook.

THE high price and shortage of fuel, together with the tendency for still higher prices, has made the engineer consider the necessity of using the cheaper grades of fuel and of making of a more thorough analysis of plant performance.

The question of boiler and grate performance has been covered in some detail in a previous article in *Power*, and in this article it is the writer's purpose to discuss over-all plant efficiency so that the relation between the various factors entering into the problem may be readily determined with fair accuracy.

Individual calculations showing the various relationships are far from complex, as will be seen from the formulas given, but the working up of any considerable amount of derived data makes the task irksome.

The charts, Figs. 1 and 2, materially simplify the problem of deriving quantities that cannot be obtained directly from the station log.

The formulas from which the following problem is worked out and upon which the charts are based, are as follows: Let

B = B.t.u. per pound of dry fuel;
E = Evaporation from and at 212 deg. F.;
W = Plant water rate, lb. per kw.-hr.;
F = Pound, dry fuel per kw.-hr.;
T = Thermal efficiency of plant, per cent.;
t = Combined efficiency of boiler and furnace;
970.4 = B.t.u. per lb. steam from and at 212 deg. F.;
3415 = B.t.u. in one kw.-hr.

Then

$$E = \frac{B \times t}{970.4} \qquad F = \frac{W}{E} \qquad T = \frac{3415}{B \times F}$$

Problem: Assume that a plant is using 14,000-B.t.u. coal, has a combined boiler and furnace efficiency of 80 per cent. and a plant water rate of 16 lb. per kw.-hr. Find the over-all plant efficiency, cost of steam per thousand pounds and the cost of fuel in mills per kw.-hr.

Solution: $E = \frac{14{,}000 \times 0.80}{970.4} = 11.5$ lb. steam per pound of fuel; $F = \frac{16}{11.5} = 1.39$ lb. fuel per kw.-hr.; $T = \frac{3415}{14{,}000 \times 1.39} = 17.6$ per cent. plant efficiency. With fuel at $4.50 per ton, the cost of the fuel item per kilowatt-hour would be $\frac{4500}{2240} \times 1.39 = 2.79$ mills. The cost of steam per thousand pounds would be $\frac{2.79 \times 1000}{16} = 17.5$ cents.

Where a number of such problems are to be worked out, or when it is desired to compare the values of coals of various prices and heat contents on a cost per kilowatt-hour basis the use of curves is much more convenient.

Fig. 1 is a quadrant chart from which may be obtained the evaporation per pound of fuel, pounds of fuel per kilowatt-hour and plant efficiency when the heat content of the fuel, combined boiler efficiency and plant water rate are shown.

Fig. 2 is worked out to show the cost of steam per thousand pounds and the cost of fuel per kilowatt-hour, in mills when the heat content of the fuel, combined efficiency and cost of coal are known. The use of the curves may be illustrated by the solution of the following problems:

Problem 1: Assume the same conditions as shown previously when formulas were used; namely, 14,000-B.t.u. coal at $4.50 per ton, combined boiler and furnace efficiency 80 per cent., plant water rate 16 lb. per kw.-hr. Find evaporation per pound of fuel, pounds of fuel per kilowatt-hour, plant efficiency, cost of steam per thousand pounds and cost of fuel per kilowatt-hour.

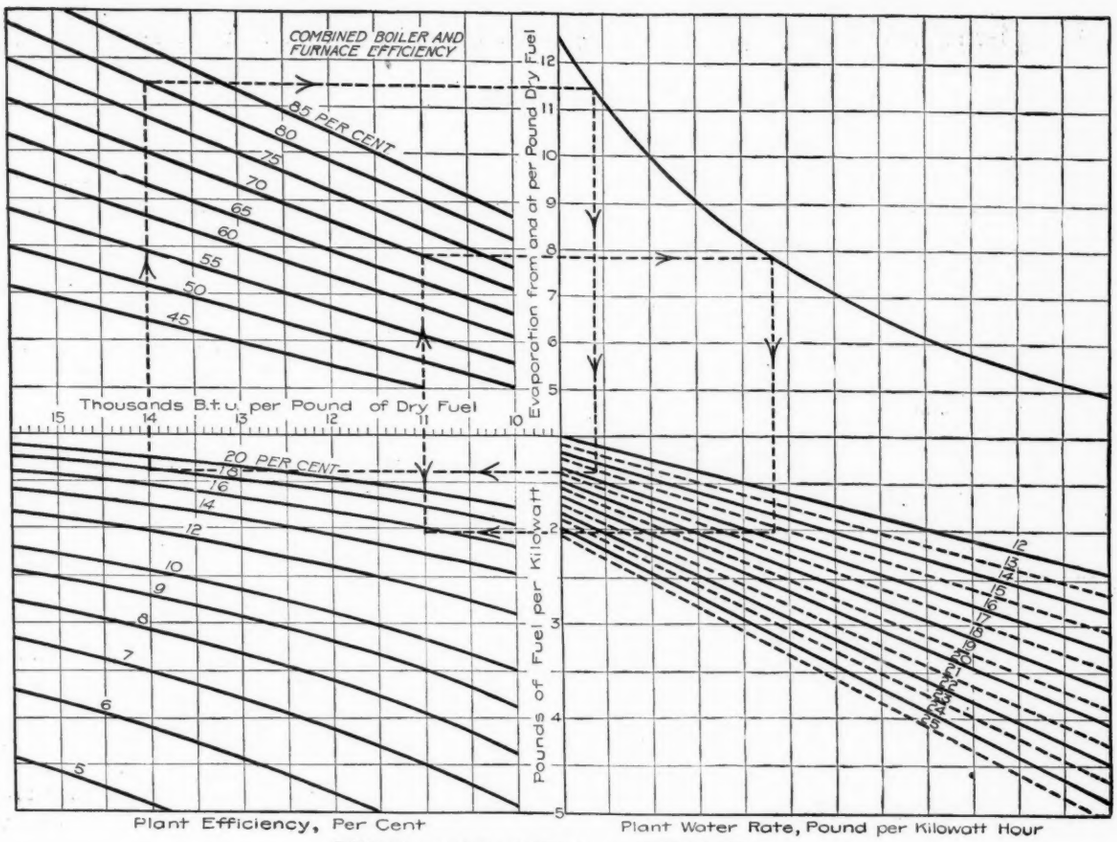
Solution: Fig. 1; from the 14,000-B.t.u. point project upward to the 80 per cent. efficiency line, then horizontally and read if desired the equivalent evaporation as 11.5 lb. steam per pound of fuel. Continue horizontally to the transfer curve and then downward to the 16-lb. water-rate line. Project horizontally to the left to the vertical scale and read 1.40 lb. of fuel per kilowatt-hour; continue horizontally to the line passing through the original 14,000-B.t.u. line and read the plant efficiency as 17.6 per cent.

Fig. 2; from the 14,000-B.t.u. line project upward as before to the 80 per cent. efficiency line, horizontally to the transfer curve, then downward to the $4.50 coal line. Project horizontally to the left and read on the vertical scale, cost of steam as 17.5c. per thousand pounds; continue horizontally to the 16-lb. water rate line, then vertically downward to the scale and read cost of fuel as 2.79 mills per kilowatt-hour.

Problem 2: The plant assumed is using 14,000-B.t.u. coal at $4.50 per ton, but has a chance to buy 11,000-B.t.u. coal at $2.50 per ton. Would it be advisable to purchase the poorer coal and what would be the maximum price that could possibly be paid for this grade of fuel and still maintain a fuel cost of 2.79 mills as at present?

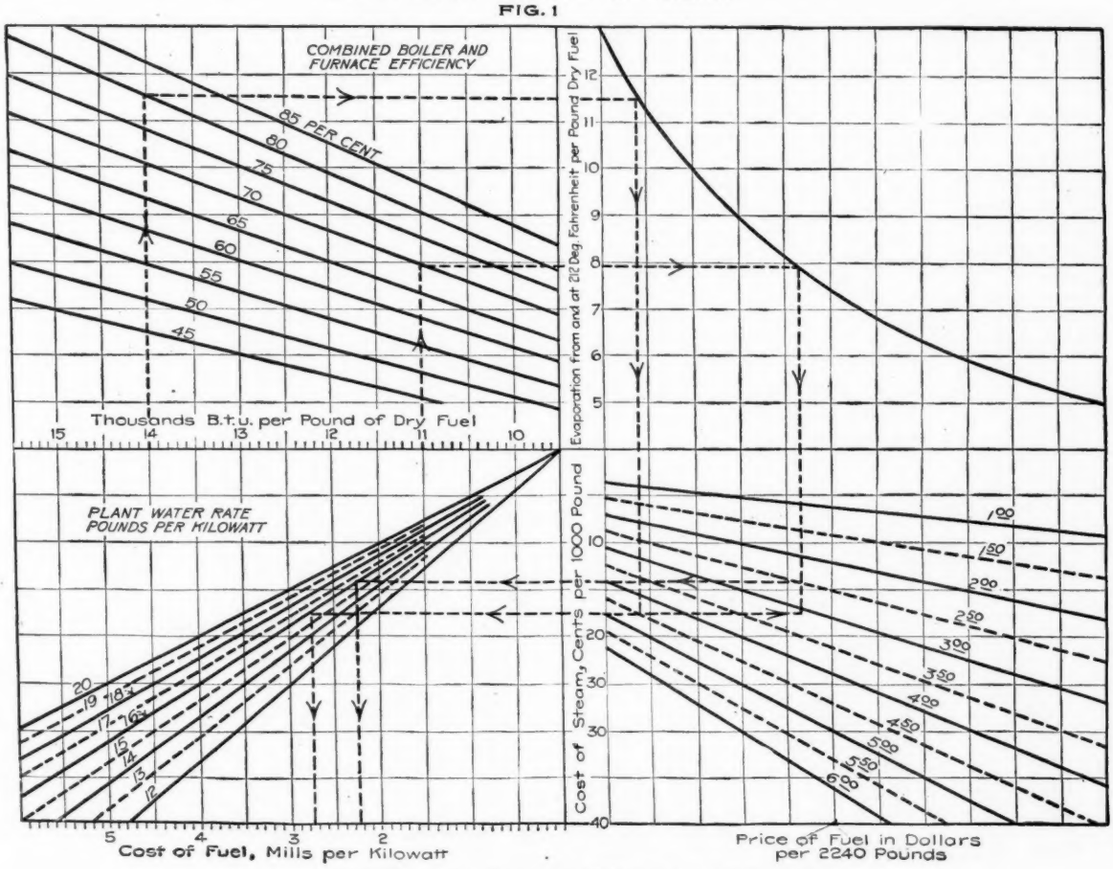
Solution: Performance tests on the 11,000-B.t.u. coal show that the boiler and furnace can develop an efficiency of only 70 per cent. as against the 80 per cent. that now obtains. Use the charts as described and read equivalent evaporation as 8 lb. steam per pound coal, cost of steam 14c. per thousand pounds; cost of fuel as 2.25 mills per kw.-hr. This compares with a present cost of 2.79 mills in the case of the 14,000-B.t.u. coal and is advantageous.

To obtain the maximum price that could be paid for the 11,000-B.t.u. coal, continue downward from the point on the $2.50 line to the intersection of a hori-



POWER PLANT THERMAL EFFICIENCY

FIG. 1



POWER PLANT FUEL COST PER KILOWATT

FIG. 2

CHARTS FOR DETERMINATION OF PLANT EFFICIENCY AND FUEL COSTS

zontal line corresponding to a cost of 2.79 mills and 16 lb. water rate and read maximum cost of 11,000-B.t.u. coal as $3.10.

From the operating engineer's point of view the following problem will be of somewhat more interest. Given a plant with a water rate of 18 lb. per kw.-hr., coal consumption 3 lb. per kw.-hr. and coal of 11,000-B.t.u. content at $1.50 per long ton. Find the evaporation, combined boiler and furnace efficiency, over-all plant efficiency, cost of steam and cost of fuel per kilowatt-hour. The evaporation will be = 6 lb. steam per pound of coal. With this data the following quantities may be read from the curves: Combined efficiency = 53 per cent., over-all plant efficiency = 10.5 per cent.; cost of steam per thousand lb. = 11.5c.; cost of coal per kilowatt-hour = 2.05 mills.

The Electrical Study Course—Adjustment of Voltage or Balancer Sets

Shows how the voltages of the balancer machines are affected by unbalancing of the load and describes methods of overcoming changes of voltages due to this cause.

THE balancer sets illustrated in the preceding lesson had the field coils of the two machines connected in series across the outside supply wires, as shown in Fig. 1. Unless the field coils and magnetic systems of the machines were absolutely identical, such an arrangement would not be found practicable, as there would be no way of adjusting the individual voltages of the machines if they proved to differ slightly; any change in the field current of one would mean a like change in that of the other, causing the voltage of the machines to change in unison.

To provide the requisite amount of adjustment, the fields would have to be connected in some such manner as Fig. 2, in which each field is connected across its own machine in series with a rheostat.

The field current of one machine can now be changed without affecting that of the other, and consequently the two voltages can be regulated independently of each other. This connection has objections which are overcome by connecting the field winding of machine G_1 across the terminals of G_2 and the field of G_2 across the terminals of G_1, as shown in Fig. 3. The reasons for the unsatisfactory results obtained with the former method and the manner in which these drawbacks are avoided by the latter will be made clear in what follows.

In the preceding lesson it was shown that, when a three-wire system, such as that in Fig. 1, carried an unbalanced load, the voltage across the more heavily loaded side would be less than the voltage across the more lightly loaded one. This effect is considerably more accentuated when the connections are those of Fig. 2, since the decrease or increase in voltage across the lines affects the field current. For example, let us suppose that while no lamps are turned on the voltages of machines G_1 and G_2 have been adjusted by means of their field rheostats R_1 and R_2 until they are both the same, and that load is then put on the system in such a way that more lamps are turned on between A and N than are turned on between N and B, as in Fig. 4. The voltage across AN will thereby be caused to decrease while that across NB increases. That is, the voltage across an decreases and that across nb increases, and consequently the current through the field winding F_1 will be decreased while that through F_2 will be increased. The voltage of G_1 will therefore suffer a still further decrease, just as in the case of any self-excited shunt generator, while the counter-voltage of G_2, which is running as a motor, is increased.

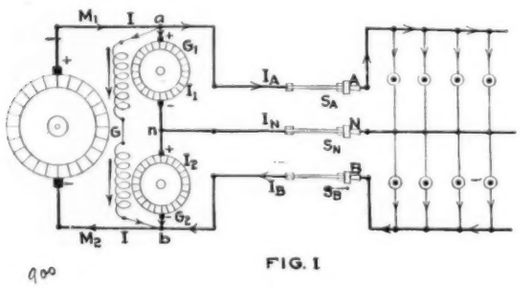


FIG. 1

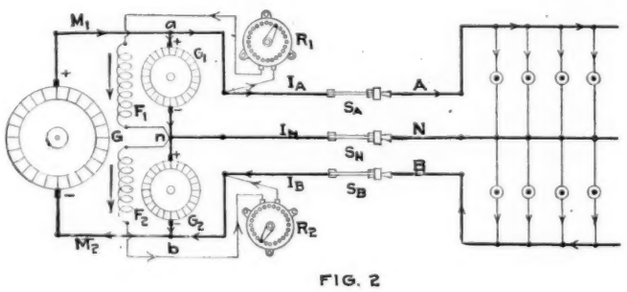


FIG. 2

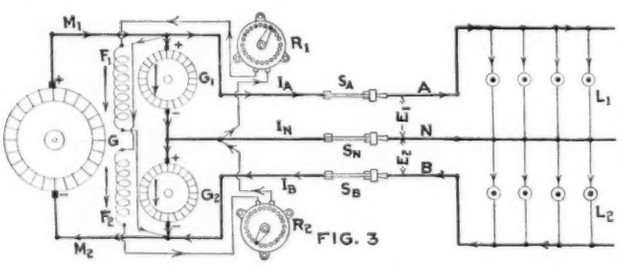


FIG. 3

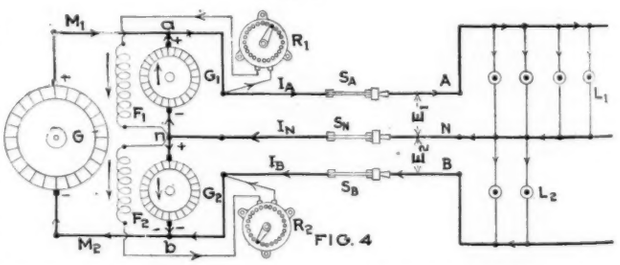


FIG. 4

FIGS. 1 TO 4. DIAGRAMS OF CONNECTIONS FOR SHUNT BALANCER SETS ON A THREE-WIRE SYSTEM

When the field currents of the machines are the same, the generated voltage of the generator and the counter-electromotive force of the motor are nearly equal. Also the terminal voltage of the generator is its generated voltage minus the voltage drop due to its armature resistance, the same as in any generator supplying a load; while the terminal voltage of the motor is its counter-electromotive force plus its voltage drop, in the armature, which is true for any motor. But in the case under consideration—namely, that of Fig. 2—it has just been shown that the generated voltage of the

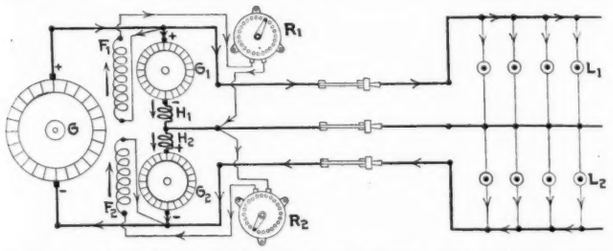


FIG. 5. COMPOUND-WOUND BALANCER SET CONNECTED TO BALANCED LOAD

generator and counter-electromotive force of the motor no longer remain equal when the load on the system is unbalanced due to the field currents in F_1 and F_2 not being equal. This makes the difference between E_1 and E_2 considerably greater than if the generated voltages of both machines were the same.

The difference in voltage between E_1 and E_2 would of course depend on the difference in the loads on the two sides of the system. It would never be very great even for a considerably unbalanced condition, but a fluctuation of even a few volts is objectionable in the case of a lighting load. A very simple way to overcome the difficulty is, as already stated, to connect the field winding of G_1 to the armature terminals of G_2, and vice versa as in Fig. 3. In this case a drop in voltage across G_1 will decrease the current through F_2 and consequently reduce the generated voltage, in this case the counter-electromotive force of G_2, and an increase in voltage across G_1 will have the opposite effect. Similarly, a change in voltage across G_2 will affect the current through F_1 and hence the generated voltage of G_1.

As an illustration, let us suppose that the loads L_1 and L_2, Fig. 3, are balanced and that the voltages of G_1 and G_2 have been adjusted to the same value by means of the field rheostats R_1 and R_2, under which condition the generated voltages or counter-electromotive force E will be the same in both machines. Now assume that load L_1 is increased or L_2 decreased; then, as already explained, G_1 will operate as a generator and G_2 as a motor. The terminal voltage E_1 of G_1 will therefore tend to decrease and the terminal voltage E_2 of G_2 will tend to increase. However, as soon as E_1 begins to decrease, the current through F_2 decreases and consequently the counter-electromotive force E of G_2 becomes less, thereby causing E_2 to be smaller than it would be if E remained the same. Also, as soon as E_2 begins to increase, the current through F_1 also increases, and hence the generated voltage E of G_1 increases. The value of E_1 will therefore be greater than it would be if E had remained the same in both machines.

From these facts it is evident that the result of connecting the field windings as in Fig. 3 is precisely the opposite of that obtained when they are connected as in Fig. 4; that is, that while in the latter case the difference in the voltages E_1 and E_2 occasioned by an unbalancing of the load is accentuated as compared with the conditions of Fig. 1, it is actually diminished in the former case. The operation of the balancer set is therefore much more satisfactory when the connections of Fig. 3 are used.

Another method of stabilizing the voltages across the two sides of the balancer set is to use compound-wound instead of shunt-wound machines. The connections would then be made as shown in Figs. 5 and 6. From the connections in Fig. 5 it is seen that when the load is balanced, the two machines of the balancer set are operating as differentially connected compound motors; that is, the shunt-field ampere-turns oppose those of the series-field winding. When the load is unbalanced, as in Fig. 6, in the machine that acts as a generator (in this case G_1) the currents in the two field windings have the same direction, but the motor fields remained in opposition. The latter condition tends to increase the speed of the motor and with it the speed of the generator, which, if the field strength of the generator remained constant, would cause the voltage to increase across the terminals of G_1. However, the series-field winding is assisting the shunt field, therefore as the load is increased the voltage of G_1 will also be increased. Hence the voltage of G_1 will be increased from two sources, one the tendency of the machines to increase in speed and also due to the generator field increasing in value from the compounding effect of the series winding. The effect of compounding is therefore similar to that found when the fields of shunt machines are interchanged, in that the unbalancing of the load causes the generated voltage of the generator to increase and the counter-electromotive force of the motor to decrease, thereby causing the terminal voltages E_1 and

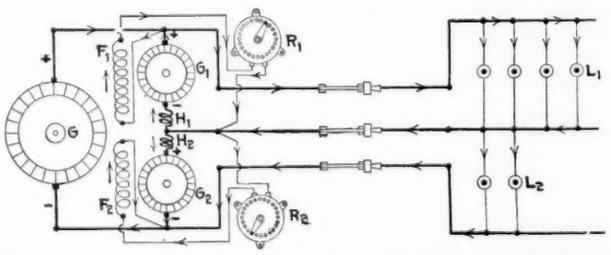


FIG. 6. COMPOUND-WOUND BALANCER SET CONNECTED TO UNBALANCED LOAD

E_2 to remain practically constant irrespective of the degree of unbalancing.

So far we have only considered whether G_1 was running as a generator and G_2 as a motor, or vice versa, without investigating very closely the value of the current delivered and taken by each, and without reference to the exact effect on the speed of the set. We will now take up these points in the order mentioned.

Since the arrangement of Fig. 1 is simpler than that of any of the others, we will make use of it in the discussion of current distribution. It is, however, to be understood that the argument applies equally to any of the other methods of connection. When the system is balanced, we have a generator G supplying current

to a number of lamps and to two motors G_1 and G_2 connected in series. When the system is unbalanced, we have G operating as a generator, and also one of the machines G_1 or G_2 operating as such, being driven by the other, which continues to run as a motor under increased load. However, G must furnish all the power used in the system since it is the only machine that is connected to a prime mover, such as an engine or turbine. Whatever current is taken by G_1 or G_2 running as a motor to drive its mate as a generator must be supplied from G, since there is no other source of power.

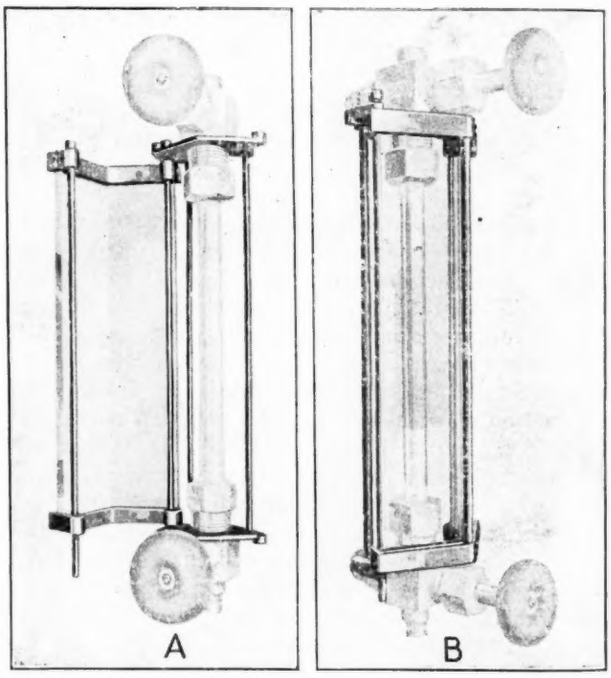
When the load is balanced, there will be no current in N and the currents I_1 and I_2 through G_1 and G_2 will be the same. The current in the mains M_1 and M_2 will therefore be the sum of the current I_1 or I_2 and the current I_A or I_B of the outside wires; that is, $I = I_1 + I_A = I_2 + I_B$. When the load is unbalanced I_A is no longer equal to I_B and hence a current I_N flows in the neutral. The current I in M_1 must of course be equal to I in M_2 in any case, so that the differences between I_A, I_B and I_N must be taken care of by the balancer set. Just how the currents are distributed will be taken up in the next lesson.

In the problem of the preceding lesson it was required to find the current in the three lines of a 115-230-volt three-wire system that has thirty-two 20-watt lamps connected across one side and twenty-four across the other; also to find the current in the outside wires and the voltages across the two sides of the system if the neutral wire were to become open-circuited. The current taken by each lamp would be its input divided by the voltage, or $\frac{20}{115} = 0.174$ ampere. The load across one side would therefore be $32 \times 0.174 = 5.57$ amperes, and that across the other $24 \times 0.174 = 4.18$ amperes. The former would be the current through one of the outside wires and the latter that through the other, while the current through the neutral would be their difference, or $5.57 - 4.18 = 1.39$ ampere. If the neutral were to be opened the current would be found by dividing the outside voltage—namely, 230 volts—by the total resistance connected between the outside wires, which would be the sum of the resistances across the two sides. Since each lamp takes 0.174 ampere, its resistance must be $\frac{115}{0.174} = 661$ ohms. Consequently, the resistance across one side of the system will be $\frac{661}{32} = 20.7$ ohms and that across the other $\frac{661}{24} = 27.6$ ohms, making the total $20.7 + 27.6 = 48.3$ ohms. The current in the outside wires will therefore be $\frac{230}{48.3} = 4.76$ amperes. The voltage across each side will be the current times the resistance, which gives $4.76 \times 20.7 = 99$ volts across one side and $4.76 \times 27.6 = 131$ volts across the other.

The distance between the generator G and the balancer set in Fig. 1 is $\frac{1}{2}$ mile. If the maximum load to be supplied is 100 amperes at 110 volts and the drop in the mains M_1 and M_2 is not to exceed 10 per cent., neglecting the losses in the balancer set, what size wire would have to be used in the mains M_1 and M_2?

Durabla Gage-Glass Shield

A new gage-glass shield possessing desirable features of safety and unobstructed view has been developed recently by the Durabla Manufacturing Co., 114-118 Liberty St., New York City. The device consists essentially of two laminated glasses set in cast retainers, forming a V-shaped protector over the front of the gage-glass. The shield is hinged to the water gage and can be swung freely to either side when it is desired to insert a new gage-glass. The closed and open positions of the shield are shown at *A* and *B* respectively. The protecting plates are made up of laminated glass $\frac{3}{8}$ in. thick and $2\frac{1}{2}$ in. wide, the length varying to meet the requirements of the gage to which they are applied. The plates consist of three independent layers of glass with a transparent compound between. It is said that they will withstand the bursting of the gage-glass or



OPENED AND CLOSED POSITIONS OF SHIELD

a heavy blow from boiler-room tools. Even if the exterior layers are cracked or checkered, the plate as a whole stands up and the individual particles are held in place by the compound so that there are no flying glass or splinters to injure the attendant. When the gage-glass breaks, the outflowing steam is directed backward and away from the operator coming to repair the damage.

All metal parts are of brass so that they will not rust or corrode, but will retain their original pleasing appearance. The vertical members of the protector are brass rods of small diameter. From either side there is no obstruction of the view, and even when directly in front of the gage the water level is still visible, the small rod at the apex of the V being only one-third the diameter of the gage-glass.

The design of the shield had four objects in view: Safety to the attendant, protection of the glass from mechanical breakage and cold drafts, unobstructed view and simple application.

Geyser Boiler Cleaner

Keeping boilers clean is an important step in obtaining efficient operation of the plant. If a boiler's sheets are kept free from mud and scale, not only is the heat given off by the burning fuel more rapidly absorbed by the water in the boiler, but the plates are prevented from overheating. Cooling down and washing out of boilers at frequent intervals is to be avoided where possible, but such practice is necessary where muddy water is used or water containing scale-forming salts.

For the purpose of removing the deposits from the feed water a steam-boiler cleaner, for use with Scotch marine boilers, known as the Geyser, is manufactured by the Geyser Boiler Appliance Co., Detroit, Mich. This apparatus is simple in construction, and its application to a boiler is shown in Fig. 1. The system consists of a number of collecting nozzles attached to pipes so as to distribute them along the bottom of the boiler shell. See Fig. 1. These nozzles are piped to a valve chamber, Fig. 2, that is provided with three ports, one on each side and one at the top.

When raising steam in a Scotch-marine boiler, heat is imparted to all of the water above the grate line, which consequently soon acquires a high temperature. The valve chamber of the cleaner being placed in the top of the boiler, to which is fitted the conductor pipes, soon absorbs heat from the surrounding water, and

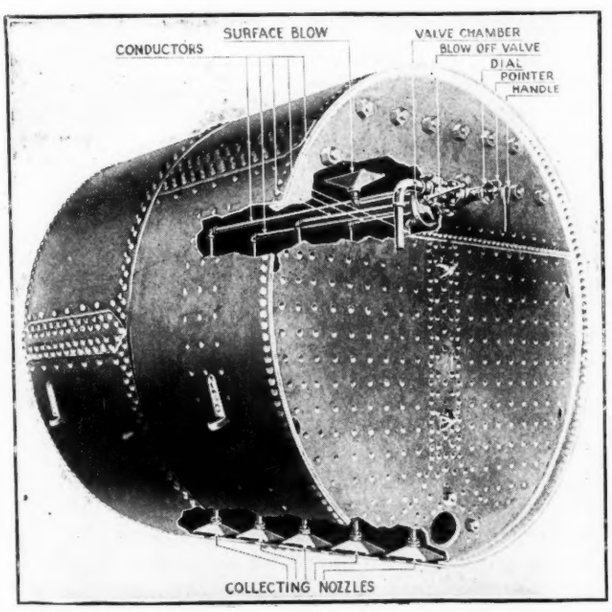


FIG. 1. APPLICATION OF THE CLEANER TO A SCOTCH BOILER

this heat is conducted to the water contained in the chamber, with the result that it starts to expand in volume, and its specific gravity changing, it soon finds its way out of the discharge port in the top of the valve chamber, and is replaced by the water in the conductor pipe, which leads to the bottom of the boiler. Thus there is a continual circulation in the system as long as there is a difference in temperature between the bottom and the top of the boiler, unless the valve closure is effected. The method of operation is as follows:

To start the circulation, open the main blowoff valve and turn the handle on the valve shaft until the pointer is even with, say, No. 1 on the dial plate. This opens communication between No. 1 collecting nozzle and the main blowoff pipe. The pressure of the boiler and the shape of the collecting nozzle produce a rapid current around and into the collector nozzle, for an area approximately six inches on each side of the nozzle. When all sediment and small pieces of scale are removed from this part of the boiler, the handle is turned until the pointer is even with the next number on the dial. The pointer is allowed to remain in this position until all solids are removed, and then the operation is repeated by moving the valve until a complete revolution is made. In this way sediment and scale-forming ingredients are removed from the bottom of the boiler and blown out through the blowoff pipe.

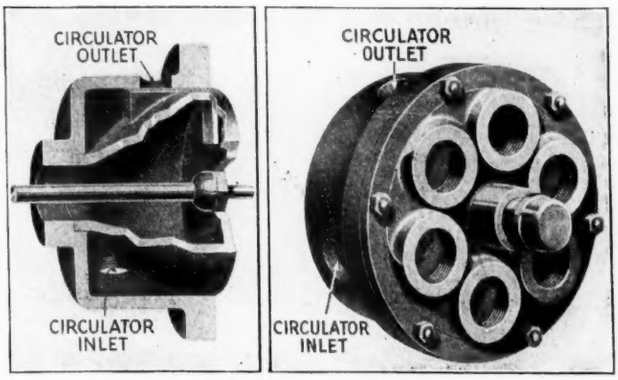


FIG. 2. SECTIONAL AND END VIEWS OF VALVE CHAMBER

Injury in Using Steam

The plaintiff, an employee in a manufacturing establishment, was directed by his superior to clean out some empty barrels in which cylinder oil had been contained. Following the directions given him, he inserted a steam flue blower in a hole in one of the barrels, permitting steam to escape from the same hole. The barrel exploded, blowing a piece of pipe through plaintiff's hip.

In an action to recover damages from the employer on account of the accident (McLeod vs. Des Arc Oil Mill Co., 206 Southwestern Reporter, 655), the Arkansas Supreme Court holds that, although plaintiff had had considerable experience in handling steam and steam engines, still he was not debarred from recovering damages on a theory that his employer had negligently omitted to give him proper instructions as to how to steam the barrels, if he actually did not know what volume of steam could be safely used in the barrels. The law charges an employer with knowledge concerning the dangers incident to employment and the duty of instructing employees concerning such dangers as are likely to be unknown to the latter through inexperience.

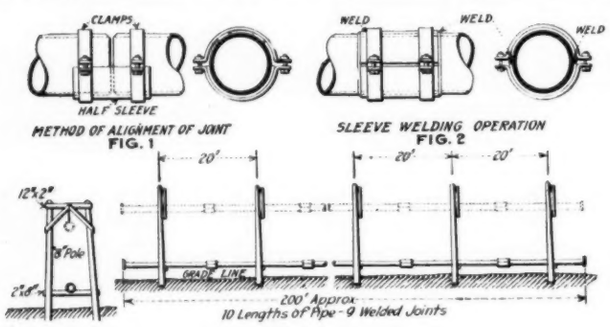
It is not economical to operate an engine when it is overloaded or when it is too large for the work it has to do. Under such operating conditions the cutoff will probably be either too late or too early in the stroke for the economical use of the steam. If the cutoff is too early there will be an increased proportional loss from cylinder condensation, and if it is too late the expansion of the steam will not be so complete.

Electrically Welded Steam Lines*

By H. R. WOODROW
Assistant Chief Electrical Engineer, New York Edison Co.

IN THE construction of the United States Government Explosives Plant "C" at Nitro, W. Va., something over ten miles of steam lines carrying 190 lb. pressure were required. Of this about five miles were 12 in. diameter or over. At the time the construction of this plant was undertaken, in the spring of 1918, the available supply of large extra-heavy flanges was very small and it was doubtful if a sufficient quantity could be obtained within the time available for completing the plant. Therefore in order to finish the work in time the Thomas E. Murray Engineering Corp., which was handling the power-section engineering work, recommended, and the War Department adopted, the use of arc welding for the connection of all the high-pressure steam and feed-water lines 6 in. in diameter and over in the plant. At the time the armistice was signed over one thousand of these joints had been completed and were in service.

All the outside mains are suspended from timber bents, at a height of approximately ten feet about the ground, as shown in Fig. 3. The welding operation was performed directly under the bents and the section of welded-joint pipe, after being tested, was raised in place by means of chain blocks.



FIGS. 1 TO 3. METHOD OF WELDING JOINTS AND INSTALLING STEAM LINE

The length of welded-joint pipe so handled averaged approximately 200 ft. and contained ten sections of mill-length pipe and nine welded joints, the two end sections having a standard Van Stone flange for connecting with fittings or valves in the completed line.

The type of welded joint used is a combination butt and sleeve joint, as indicated in Figs. 1 and 2. The butt ends of adjoining sections were scarfed off at an angle of about 45 deg. with the axis of the pipe and butt-welded. The weld was then chipped flush with the pipe surface, and a hydrostatic test of from 400 to 600 lb. was applied to the completed length. After inspection, the reinforcing sleeve was applied. The sleeves are made in halves and are die-formed of metal equal in thickness to, and of a length approximately equal in diameter to that of the pipe to which they are applied.

The welding was performed by the pencil-arc process, the current employed being 110-volt alternating, which was obtained primarily from the general supply system for the plant, carrying 6600-volt three-phase current led through transformers and secondary lines to the welding reactances, furnishing the controlling medium required for the welding operation.

The electrodes used in the butt-welding operation were slag-coated and were of the same character as those extensively used in ship welding. The welding of the sleeves was performed with a low-carbon steel bare wire. The butt weld consisted of two runs of metal, the first of No. 10 and the second of No. 8 wire, the first run being carefully cleaned free of slag, first by hammering and finally by scrubbing with a wire brush until the metal showed clean and bright before applying the second run. The sleeve weld consisted of two longitudinal welds joining the two halves of the sleeve, and a weld on each end of the sleeve completely joining the sleeve to the pipe (See Fig. 2).

The application of the sleeve was determined upon for structural reasons, as the stresses likely to be encountered in an installation of this character are practically indeterminate.

One of the problems met with in handling pipe in such long lengths is the question of accurate alignment, which was accomplished in this case in the following manner: The proper level above the ground for the pipe was determined by its accessibility to the welder, and this point was marked on each leg of each pipe-carrying bent, and timber joists were securely fastened between the legs of the bents at the proper level, as in Fig. 3. The pipe lengths, approximately 20 ft. long, were laid on these joists, and as the spacing of the bents along the axis of the pipe was 20 ft., this brought a joint between each pair of bents. The ends of the individual pipe lengths were then brought within about $\frac{1}{10}$ of an inch of contact and lined up and clamped securely in position by means of a half-sleeve applied to the under side of the pipe and fastened by straps to each end of each pipe section (See Fig. 1).

This left the upper half of the butt joint ready for the first run of the weld. When one-half of the first run was completed on each joint, the clamps and the sleeve were removed and the entire 200-ft. length of pipe was rolled on the joists until the other half of the butt joint was uppermost, and the first run was then completed. In consequence of the fact that it was possible to turn the pipe at will thereafter, the second run of the weld was made continuous.

It takes one welder about three hours to completely butt-weld and sleeve a 12-in. joint. The time required for other sizes would be in proportion to their diameter.

I feel that the use of the electric welding is going to be a very important feature in the development of power stations where the tendency is going to higher steam pressures, in the neighborhood of 600 lb., as welded joints can unquestionably be made stronger than any other connection, and are absolutely leakproof.

No man who frets and chafes at his work can do justice to himself, his job or his employer.

*Presented in the discussion on electric welding at a joint meeting of the American Institute of Electrical Engineers and the American Institute of Mining Engineers, held during the Midwinter Convention of the American Institute of Electrical Engineers, New York, N. Y., Feb. 19, 1919.

EDITORIALS

Interpole Direct-Current Machines

IN THE development of electrical apparatus during the last twenty years many changes in the design and construction of direct-current machines have taken place. If a typical modern direct-current motor of from five to one hundred horsepower rating based on a certain speed be compared with a machine of the same horsepower and speed rating, built fifteen or twenty years ago, two points of difference will at once be apparent. First, the modern motor will be smaller than the old machine; and second, it will, in all probability, have interpoles, whereas the old machine will not. The first of these two points of difference is the effect, of which the second is, to a large extent, the cause. A better understanding of the operating conditions of the machine and a better knowledge of the electric and magnetic properties of the materials have enabled the manufacturer to make such economical use of his material as to reduce very considerably the quantity required to make a machine that will accomplish a given result. Of all the causes that have contributed toward this end, no one thing has had greater influence than the introduction of interpoles.

Commutation was formerly much more than at present the bugbear of direct-current machinery. By a sufficiently liberal use of materials in the noninterpole type, good commutation at a certain speed was accomplished. But it is not always desirable that a motor run at one speed only. By the use of an adjustable-speed motor such intermediate speed-changing devices as gears, belts, step pulleys, etc., may often be eliminated. The average noninterpole motor will usually run satisfactorily at any speed between one hundred and one hundred and fifty per cent. of its rated revolutions per minute, but at higher speeds sparking at the brushes becomes excessive. On the other hand, an interpole motor that is designed for that purpose will operate properly at any speed between one hundred and four hundred per cent. of its rated revolutions per minute.

Not only is it true that the range of speeds over which a motor will operate satisfactorily is increased by the use of interpoles, but the range of loads is increased as well. When a noninterpole machine is operating at a certain load, as, for example, full rated load, the commutating conditions may be ideal, but at any other load they will not be ideal unless the brushes are shifted. With interpole machines the brush position that is best for one load is best for all loads.

There are certain things about interpole machines which it is very desirable that the operating man who has direct-current machines in his charge should know. He should have sufficient knowledge of the theory of commutation so that he will understand why interpoles are used; he should be able to tell whether the interpoles in any of his machines are of the correct polarity and whether the windings are properly connected; he should know that the brushes of an interpole machine, when once correctly set, should never be shifted, regardless of changes in load, speed or direction of rotation; he should know that an interpole motor should run at the same speed in either direction of rotation and that if it does not, the brushes are not set in the neutral position; and he should know the effect on the speed and stability of his motor when its interpoles are not of the proper strength and how to proceed to remedy the trouble. A careful study of the two articles on "Interpole in Direct-Current Machines," the first one of which appears on another page of this issue, will give him this knowledge.

Capacities of Large Steam Turbines

ELSEWHERE in this issue appears a paper on steam-turbine design, by J. F. Johnson, which our readers will appraise as a valuable as well as a bold piece of engineering literature. It is bold because of the frankness with which the author goes into detail about the experience in the operation of reaction turbines of thirty thousand kilowatts and greater.

Calling attention to the fact that turbines of fifteen thousand kilowatts capacity did not appear until about 1908, while today many large plants have turbines of thirty thousand kilowatts or greater capacity, he asks: "Has this growth been natural, logical and healthy, or has it suffered temporarily from overstimulation which is destined to result in a relapse, or reversion to smaller sizes?"

The growth has been logical, broadly speaking, if not as "healthy" as some would desire. While some engineers may state that the growth has not been natural, inferring that it is undesirable to go beyond a certain capacity, say thirty thousand kilowatts, consensus of opinion would indicate that this is not so and that there will not be a reversion to comparatively small sizes.

Of course one may get too many eggs in one basket. But when has one got too many? Because he has many it does not follow that he has too many. It has helped operating costs very materially to enlarge upon the unit capacities of prime movers and boilers. And who does not recall with what anxiety on the part of the profession generally the large Delray boilers were put in service? It was a daring thing to jump from the customary boiler of five hundred horsepower to one of nearly twenty-five hundred rated horsepower, providing it with stokers that made it possible to increase the rating to such length that a load of eleven thousand kilowatts could be carried by it. Boilers of fifteen hundred horsepower have become more widely used for large stations than those of the size used at Delray. But one cannot find an appreciable flaw in the reliability or performance of the latter. It is more a question of adaptability. The same may be said of the turbine. The larger the load demand at one time on the station the

larger the capacity of the units installed in order to take advantage of low cost per unit of capacity. The large turbine has not only given more economical performance because of its size; but a material reduction in cost of foundations, buildings, piping and switching equipment results as compared with costs for the same output in machines of smaller capacities.

Mr. Johnson avoids consideration of the question of how far it may be advisable to go in the quest of great capacity in a single cylinder. But the question is as much a part of large steam-turbine design, application and service as stoker performance is a part of modern boiler practice. Naturally, the limit of capacity is sooner reached in a single-cylinder than in a multiple-cylinder machine. But what is that limit? Development up to date has reached forty-five thousand kilowatts in the single-cylinder turbine. Is this the limit, and if it is, why?

Electric Welding

THE possibilities of development under intensely concentrated investigation are remarkably illustrated in the progress that has been made in the application of electric welding under the tremendous stimulus created by the demands of the great war that is passing into history. The degree of importance that this use of electricity has reached is reflected in the fact that an entire afternoon session of the recent midwinter convention of the American Institute of Electrical Engineers was devoted to the subject.

Of the two methods of electric welding, arc and resistance, the former has undoubtedly undergone the greater improvement. That this should be so is quite natural, since the resistance method has for many years occupied a position of development relative to which that of the arc process might be called crude. In the research work done on the arc process it appears that the efforts have been concentrated more particularly on the type that uses a metal electrode as distinguished from the one using a carbon or graphite pencil. It was also brought out that practically all efforts had been concentrated upon the application of the process to steel welding. In fact, the great need for welding came in connection with the urgent demands of the shipbuilding program, and as a consequence a major part of the efforts of the committee under whose supervision the work was carried on, was directed toward the problem of applying the process to the needs of the steel-ship builder. However, the investigations undertaken let in a flood of light on the entire situation and points the way toward the eventual perfection of the process.

The work was begun under the auspices of the Standards Committee of the American Institute of Electrical Engineers, from which it was taken over by the General Engineering Committee of the Council of National Defense, which eventually carried on its work under the Emergency Fleet Corporation. The members of the committee are to be congratulated on the impartiality and conservatism that are reflected in its findings, which formed the basis of most of the papers presented.

That the subject is an extremely far-reaching one and that much research work is yet to be done is apparent upon considering the multitude of variables that enter into it. As in oxyacetylene welding, the chief variable is the operator, and this will probably always remain so in the case of welding that cannot be done automatically. Among the other variables are the composition of electrode used, the effect of bare versus covered electrodes, the current density used under different conditions, and the preparation of the work to be welded. There is also the choice, as in power applications, between direct current and alternating current, with advocates on each side, although the results obtained indicate that equally successful results, as regards the quality of welding, can be obtained whichever is used.

American Engineering Standards Committee

AMONG the many things the world war has taught us is that individual effort is uneconomical and costly, and if a nation is to meet the competition of the future successfully it must be through collective action, not only among industries but also among individuals. Before this collective effort can attain its greatest results, there must be a higher degree of standardization than in the past, at least within the nation itself. It is for this purpose that the American Engineering Standards Committee has recently been organized, the purpose and machinery of which were outlined by President Comfort A. Adams in his address, "Engineering and Industrial Standardization," before the midwinter convention of the American Institute of Electrical Engineers. The part of this address dealing with the American Standards Committee is published on page 337.

One of the first thoughts that must suggest itself to the reader, on reading this outline, is that the machinery of this committee is a masterpiece in American organization, comprehensive in its scope and democratic in its method of dealing with the work to be undertaken, embodying an appreciation that has been lacking in many of the standardization organizations of the past—as Mr. Adams has expressed it, "A realization that a standard must not only be rational and technically correct, but also acceptable to all those interested in its manufacture and use, and the mere promulgation of a standard by any society, however powerful, does not make it a real standard."

The work of this committee should receive the hearty support of every industry coming within its field of effort since its creation will apparently eliminate the overlapping and confusion of standards that our industries have been beset with by the many different standards committees of the numerous engineering and industrial organizations in this country today, and with the proper support and coöperation of all interested organizations, it should contribute largely to the industrial development of the nation.

Speaking of a Ford engine that was used to drive an ice-cutting machine, a reporter in one of our small-town newspapers says: "The engine went into the lake in twelve feet of water, but continued to run for about five minutes at the bottom of the lake." Fishy? Not a bit. It may have been a leftover from one of Henry's much talked of one-man submarines.

CORRESPONDENCE

Diagram Showed Lack of Oil

A new engine, when being "tuned up," seemed to be in difficulty, so I indicated it, obtaining the diagram shown. The valves were not closing properly, which seemed to show that the cylinder was not getting

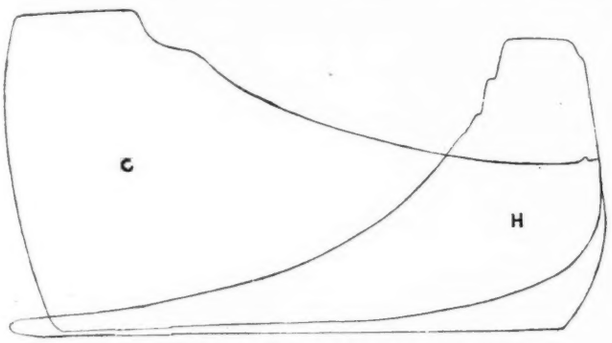


DIAGRAM FROM POORLY LUBRICATED ENGINE

enough oil. After speeding up the lubrication and waiting a few minutes, a regular diagram was obtained. It was easy then to convince the attendants of the importance of watching the cylinder lubrication.

Toronto, Ont., Canada. R. McLAREN.

Care of Economizers

In the Feb. 11 issue of *Power*, page 192, was an article entitled "Care of Economizers," by J. F. Daggett, and as indicated by the subcaption, some very helpful information was set forth. However, there was one paragraph that I am unable to understand, or, at least, to understand the condition referred to.

Quoting from the article, "If the water in the economizer gets too low, immediately open the bypass flue damper, leaving the outlet wide open." The first clause of this sentence would seem to imply that under ordinary conditions a certain water level should be maintained, and the questions I would like to ask are, Where is the point of normal water level, and what means are provided to determine if the water is too low or too high in the economizer? The necessity of knowing this would seem apparent in view of Mr. Daggett's suggestion for immediate action. Does he mean that economizers are, or should be, fitted with water-glass and try-cocks? D. E. GRANGER.

Newark, N. J.

Gate Valve Exploded

Referring to the article on page 83, of the Jan. 21 issue, I would call attention to the fact that such things often happen. It is sometimes difficult to remove a nipple from a screwed end valve without damaging the thread in the valve or on the nipple to such an extent that neither can be used again.

It is seldom that two or three persons will put the thread on the nipple the same way, but assuming that the thread in the valve is all right, that on the pipe or nipple might be a little different, and to hold a thread end tight in a fitting a little white lead can be used; and naturally, after the joint has been in use for some time the thread is so tight that the nipple can be removed only with difficulty.

If a flanged gate valve had been used, such an experience as mentioned should not have occurred, because a pair of flanges could be easily loosened. Furthermore, if at any time a nipple is removed from a standard-size gate or globe valve, the valve is in most cases deformed and not good for further use.

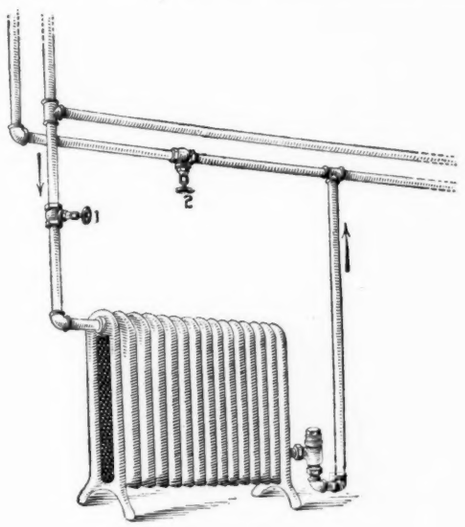
I do not agree with the argument of many engineers that so many flange connections are the causes of leaks, especially now that there are on the market many good gaskets which will answer the purpose.

In the long run it is much cheaper to use flanged fittings around the whole plant. F. C. HEYLMAN.

Martinez, Calif.

Radiators Located Below Vacuum Return Main

It is sometimes desired to heat a basement or cellar room where the steam and return piping is overhead and ceiling coils are objectionable. In this case a hot-water type radiator can be used to advantage by installing it so the drip of a return riser circulates



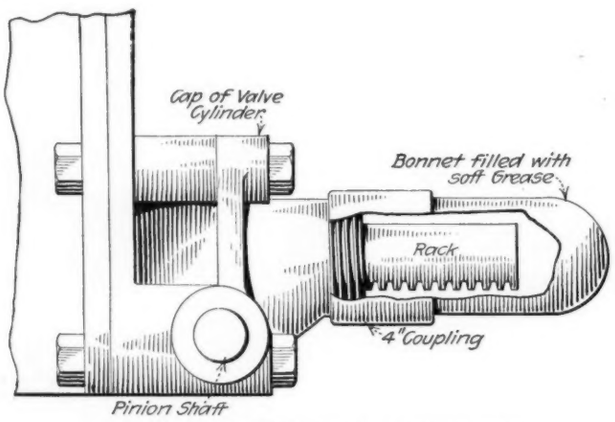
PIPING HOT-WATER RADIATOR

through it in the same manner as a hot-water radiator, as shown in the illustration. To operate, open valve 1 and close or partly close valve 2, and the hot water will then pass through the radiator and give off heat.

Brooklyn, N. Y. W. T. MEINZER.

Lubricating Rack-and-Pinion Gears

The accompanying sketch shows the device adopted by a local engineer for lubricating the rack-and-pinion gears that shift the operating valves of a pair of horizontal-cylinder hydraulic elevators in his charge. The racks are made of steel and the pinions of brass. In



RACK-AND-PINION GEAR LUBRICATOR

the original design of the machine no provision was made for getting oil to the meshing contacts of the gears in the horizontal position. On this account the wear of the pinion was excessive, necessitating frequent renewals. To correct this the engineer threaded the cap of the valve casing to receive a 4-in. pipe coupling having a cup-shaped grease receptacle attached as shown.

The engineer figures that the lubrication thus secured has increased the durability of the brass pinions tenfold. A. J. DIXON.

St. Louis, Mo.

Voltage on Generators Varies When Being Paralleled

In the plant where I am employed are three compound-wound 220-volt generators. The capacities of the three machines are 75, 200 and 300 kw. respectively, and they are arranged to be connected in parallel through three-pole switches. All three generators are steam-engine driven.

The machines give no trouble when operating in parallel, but when cutting them in or out of service the voltage varies to such an extent as to affect the speed of the motors out in the plant. Although this change in speed is for only a very short period, it is sufficient to affect the product being manufactured by the machinery driven by the motors. I would appreciate some advice from the readers of *Power* as to the best remedy for this trouble. CHARLES A. ARMSTRONG.

Philadelphia, Penn.

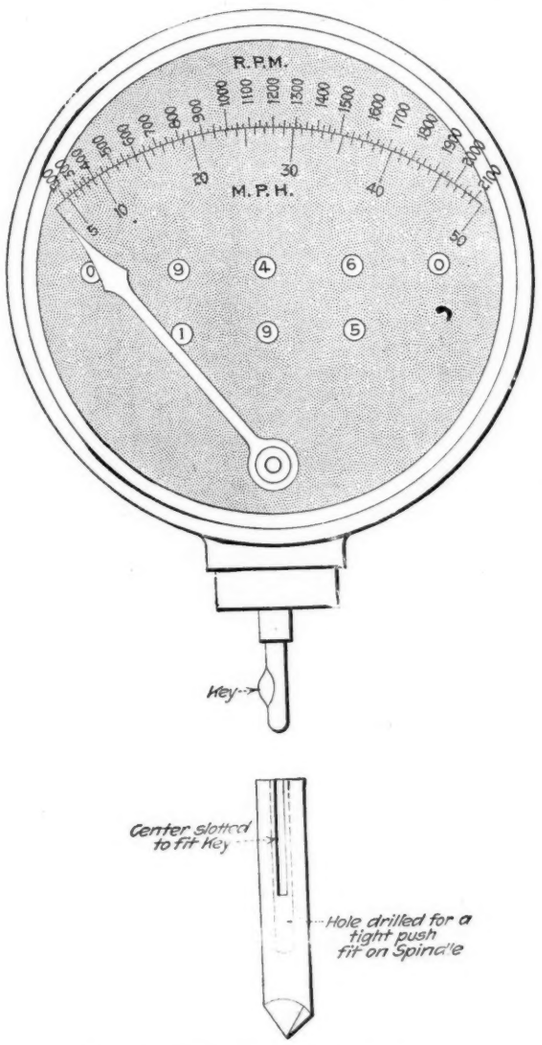
A Home-Made Tachometer

Needing a hand tachometer, I procured from the local garage an old automobile speed indicator that was in good condition and made a temporary handle to go on the spindle, so that I could turn it and count the revolutions. I then counted the number of revolutions the spindle would have to make per mile of the recording dial, which in this instance was 2560.

The next thing was to find how many revolutions per minute were equal to one mile per hour: $2560 \div 60 = 42\frac{2}{3}$ r.p.m. = 1 mile per hour. I then pasted a piece of tracing cloth over the old dial and worked out the points on the scale corresponding to 200 r.p.m., 300 r.p.m., etc., up to 2100 (the limit in this case was 50 miles per hour or $2133\frac{1}{3}$ r.p.m.) thus: 200 r.p.m. $= \frac{200}{42\frac{2}{3}} = 4.72$ miles per hour; 300 r.p.m. $= \frac{300}{42\frac{2}{3}} = 7.08$ miles per hour, etc.

I then marked these points on the tracing cloth corresponding to the miles per hour and marked the r.p.m. opposite, and after the whole scale was worked out, subdivided these divisions into smaller divisions equal to 25 r.p.m., thus completing the scale.

A piece of round steel was drilled the exact size of the



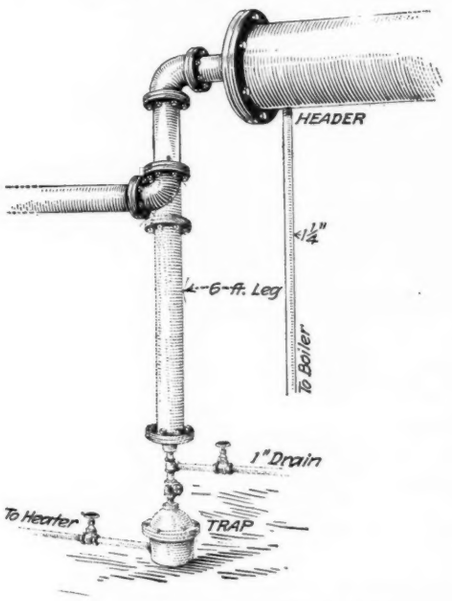
GRADUATIONS ON TACHOMETER DIAL

spindle, and a slot made in it to fit the key on the spindle. Having got this fitted, it did not take long to file up a diamond-point center and harden it. This completed a handy speed indicator, which is accurate enough for most purposes. D. JAMES.

New York City.

Changes In Header Piping

The change in piping illustrated on page 219 of the Feb. 11 issue was unnecessary. I have the same kind of a header, with a 6-in. outlet connected like the one shown, and it was only necessary to put in a 1¼-in. drip



DRIP ANSWERS AS WELL AS TRAP

pipe near the end of the header and connect it to the boiler. It gives the results desired, there is no trap to cause trouble and the extra radiating surface is not excessive. W. H. WAKEMAN.

New Haven, Conn.

[The elbow in the pipe line shows the original connection. The lighter shaded tee and drop leg represent the changes made by the engineer.—Editor.]

Trouble with Belt Tighteners

In the Dec. 10 issue, page 856, J. S. Eckert described the trouble he was having with idlers used with a couple of belt drives, and in the Jan. 21 issue, page 101, he reports that the trouble was overcome by turning off the crown of the idler pulleys. The fact that the problem was solved by turning the crown off the idler pulley would indicate that the crown was the cause of the difficulty, but was it? This is but one of those half-truths which, someone has declared, are more dangerous than untruths.

When a belt gives trouble by running off the pulley, it should be ascertained whether the shafts are parallel and if the belt is true. A slipping belt or one out of true will run off a crowned pulley quicker than it will run off a straight-faced pulley. This is because of the tendency of the less-stretched edge to run up on the crown.

The belt manufacturers had informed Mr. Eckert that his trouble was partly due to the excessive width for such a thin belt (belt 48 in. wide, ⅜ in. thick). As suggested, the trouble seems to have been caused by uneven stretching of the belt, which has the same effect as if the pulleys were out of line. Turning off the crown of the pulley did not remove the cause of the trouble. Crown on a pulley will not cause a properly installed belt to leave the pulley, but has the opposite effect—witness the many drives operating successfully with crowned pulleys. C. O. SANDSTROM.

Kansas City, Mo.

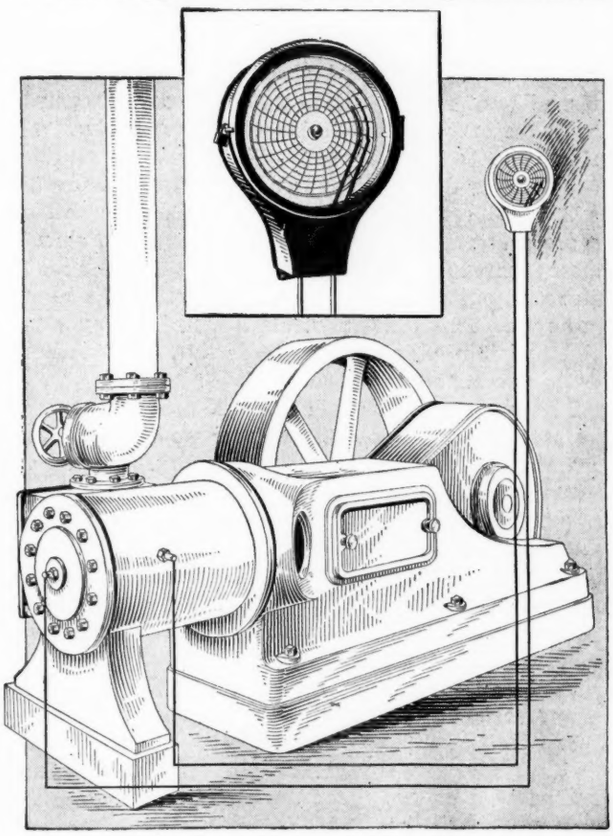
Better Cylinder-Oil Testing Methods Are Needed

Professor Trink's letter on page 644 of the Oct. 29 issue of *Power* calling for a discussion of better methods of lubrication tests of steam cylinder oils was read with interest, and I have been disappointed that it has called forth no more discussion than has appeared so far.

It seems to me that the proper place to test a cylinder-lubricating oil would be in the cylinder of the engine in which it is to be used. The problem then would be one of devising some means of ascertaining the internal condition of the cylinder at all moments during the test.

Friction, as we all know, produces heat and a lack of lubrication produces friction. Then why not devise a method of determining what portion of the heat of the cylinder is due to steam temperature and what portion is due to friction, introducing oil until the friction is reduced to a minimum.

I would suggest attaching a recording thermometer



PROPOSED METHOD OF TESTING CYLINDER LUBRICATION

to the center of the cylinder wall and one to the center of the cylinder head, having both temperature lines drawn on the same chart at the same time. The bulb attached to the head would indicate (nearly) the temperature due to steam, and the bulb attached to the center of the cylinder wall (where the piston speed is the

greatest) would give the temperature due to steam temperature plus that due to friction.

Assuming that under normal operating conditions both instruments recorded the same temperature, then a lack of proper lubrication would show itself in a rise on the line drawn by the thermometer attached to the cylinder wall; or assuming that the center of the cylinder wall indicated normally a slightly higher temperature and the steam pressure changed periodically, then it would be possible to note a lack of lubrication by a wider divergence of the two lines.

New York City. WILBERT WALTON CRANFORD.

Hand-Damper Regulation

The letter on page 182, of the Feb. 4 issue of *Power*, on hand-regulation of dampers, by T. Henwood, cannot be too highly commended. No one knows better than the operating engineers who, under the direction of the United States Fuel Administration, acted as volunteer inspectors of the many abominations in the shape of hand-damper control apparatus in use throughout the country. In some plants the damper is never used except when a boiler is taken off the line and it is found that a stick, a brick or perhaps a poker regulates the damper position.

If the owners of plants could only realize what an enormous saving in fuel can be effected by the judicious use of the draft control, they would soon see the advisability of making such control as easy of operation as is the opening and closing of the feed valve. Then if a gage is installed that will show the strength of the draft or differential through the fire, the first step will have been accomplished. A few dollars will purchase a steam-flow meter for boiler use, and then the most ignorant fireman will soon realize that for a given steam output a certain draft, as shown by the gage, is required. This draft requires a certain damper position and it needs no expert to determine just what to do to obtain these conditions.

Perhaps the owner will answer such an argument by saying that his operating force would soon tire of the constant observation of such devices. Has he ever given thought as to starting a bonus system for his power-house employees? Some think that this would require an endless amount of bookkeeping and thus claim that such a system could not be adopted in their plants on account of the difficulty of charging costs properly. Almost every steam plant has a unit of output, whether it be barrels of flour, sacks of cement, square feet of heating surface, kilowatt-hours, gallons of water pumped, or any manufactured commodity.

Let the owner look over his coal bills and find what they were at a time when the plant was new, or when he had what he considered the best of engineers. Then let him take the coal bill during that period as a criterion, go to his engineer and tell him that any saving of coal will be split "fifty-fifty" between the office and the operating force. Also explain that a saving of half a ton of coal a day at $4 a ton will mean a division of $1 between the day engineer and fireman and the night engineer and fireman.

Only 25 cents a day to be sure, but that means $7.50 per month, and after the first month that the firemen receive the bonus just watch their "smoke." Thereafter watch them get torches or candles and go after those leaks. See how they will cut the damper to the minimum amount during cleaning periods so as to reduce the inrush of excess air into the furnace as much as possible; also expect an urgent call for boiler-wall cement. Examine the ash pile and see how the combustible matter in it has decreased. Also see how soon it will be noised around that such and such a plant is a good place in which to work, and not only will there be an increase in the savings from month to month, but the very personnel of the crew will be better, with obvious results.

Of course the owner must do his part. He can do a lot of educational work by putting up a few signs such as: "Excess Air Means Decreased Bonus"; "Damper Wide Open With Furnace Doors Open Means a Loss of Fuel"; "Watch for Cracks in the Settings"; "Don't Let Safety Valves Blow"; "Coal in Ashes Means a Loss."

A few such signs will go a great way toward educating the men, and when they know the effect on the amount of bonus, the result is magical.

Louisville, Ky. JOHN F. HURST.

Dividing Box with Condensing Head

The dividing box illustrated on page 132 of the Jan. 28 issue of *Power* has, I think, one serious disadvantage. The V-shaped columns of water discharging over the weirs of the intake lines to the heaters trap a great deal of air.

Condensate absorbs a large proportion of this air, and if the temperature of this water is not raised to 205 deg. or over, the oxygen is not driven off. The result is increased work for the air pump of the main units.

If the discharge opening to the heater is sealed by using a gooseneck, vented on top to prevent a siphon effect, this condition can be overcome.

Brooklyn, N. Y. C. L. VANCE.

Generator Heats Excessively

There are many possible causes for Mr. Burkard's generator heating, referred to in the article, "Generator Heats Excessively," Jan. 21 issue of *Power*. If the brushes do not heat, it is not likely that the heating is caused by any inherent characteristic in them. Low insulation resistance of the generator windings, or the machine being installed in a damp place might cause heating. The bearing on the opposite end of the shaft from the commutator may be heating and the heat may travel along the shaft into the armature.

New York, N. Y. PATRICK MOLLOY.

Advantage should be taken so far as possible of low-load periods to reduce the peak-load difficulties of the plant. For instance, boilers should be blown at noon hour or other times of light load, and this is the time to fill water tanks, charge storage batteries, blow tubes, run ash and coal conveyors, etc.

Into North Dakota there are now being imported annually two million tons of bituminous coal and one million tons of anthracite, every pound of which should and some day will be replaced with fuel from the Dakota lignite field.

INQUIRIES OF GENERAL INTEREST

Size for Cold-Rolled Steel Head Shaft—What size of cold-rolled steel shaft should be used at 200 r.p.m. for receiving and transmitting 100 hp.? E. T.

The formula for cold-rolled head shafts carrying main receiving or driving pulleys and well supported by bearings is $hp. = d^3 \times$ r.p.m. $\div$ 100, in which d = diameter of shaft in inches. For 200 r.p.m. and 100 hp., the formula would become $100 = d^3 \times 200 \div 100$, from which $d = \sqrt[3]{50} = 3.684$, or $3\frac{11}{16}$ in.

Weight of Water Discharged Over V-Notched Weir—What is the formula for the number of pounds of water at 60 deg. F. flowing over a 90-deg. V-notched weir? T. E. S.

The formula for flow over a 90-deg. V-notch weir is cu.ft. per min. $= 0.306 \sqrt{h^5}$, in which h = the head of water measured in inches above the apex of a symmetrically placed V-notch made in "thin plate" or beveled for clearance on the discharge side of the wear. One cubic foot of water at 60 deg. F. weighs 62.3677 lb., and for that temperature the weight of water discharged would be $62.3677 \times 0.306 \times \sqrt{h^5} = 19.08 \sqrt{h^5}$. lb. per min.

Preference for Standard-Weight Pipe—For general power-plant work and for pressures upward of 300 lb. per sq.in., why is 6- to 8-in. standard pipe preferred to the extra-heavy? W. E. A.

Standard-weight pipe is preferred to extra-heavy on account of greater flexibility. Extra-heavy pipe is considered to be more appropriate where pipes occupy inacessible places or are especially exposed to corrosion. For 300 lb. pressure the factor of safety of standard pipe would be about $2\frac{1}{2}$, while extra-heavy would give a factor of safety of about $4\frac{1}{2}$. The selection with respect to safety must be left to the discretion of the designer.

Coal Required for Heating Air—A fan delivers 36,000 cu.ft. of air per minute through steam-heating coils. What amount of coal of 10,000 B.t.u. per lb. will be required to raise the temperature of the air from 10 deg. F. below zero to 70 deg. above zero? C. C. P.

The specific heat of dry air at constant pressure is about 0.2376 and at —10 deg. F. the weight per cubic foot would be about 0.0882 lb. As the elevation of temperature would be 80 deg., the heat required would be $36,000 \times 60 \times 0.0882 \times 0.2376 \times 80 = 3,621,252$ B.t.u. per hour. Allowing a boiler efficiency of 60 per cent. to be obtained with coal of 10,000 B.t.u. per lb., would require, $3,621,252 \div (10,000 \times 0.6) = 604$ lb. of coal per hour.

Fuse Blown on Three-Phase Motor—What would be the effects of a fuse blowing in either of the primaries or secondaries of three transformers connected in star, to a three-phase motor? B. R.

The opening of a fuse on either side of the transformer bank would leave the motor operating single-phase. If the motor is lightly loaded it will continue to run until shut down, but cannot be started again until the fuse is replaced. While the motor continues to operate single phase it will take about 100 per cent. more current in the active phase than when operating three-phase. The single-phase pull-out torque will be from 30 to 40 per cent. of what it was for three-phase operation.

Results of Evaporative Test—In an evaporative test of 10 hours' duration, three water-tube boilers having respective rated capacities of 265, 265 and 400, or a total of 930 boiler horsepower, evaporated 313,000 lb. of water fed at 166.4 deg. F. into steam at an average gage pressure of 150 lb. per sq.in. with 6 per cent. moisture. There was 57,535 lb. of coal burned with 8678 lb. of ash and refuse. What was the equivalent evaporation from and at 212 deg. F. per pound of coal and per pound of combustible and what percentage of the rated capacity was developed? P. T. J.

One pound of dry saturated steam at the pressure of 150 lb. gage, or 150 + 15 = 165 lb. absolute, contains 1195 B.t.u. above 32 deg. F., and the heat contained per pound of the liquid is 338.2 B.t.u. above 32 deg. F. Hence, each pound of the feed water at the temperature of 166.4 deg. F., for conversion into steam at 150 lb. gage pressure with 6 per cent. moisture, must have received 94 per cent. of 1195 + 6 per cent. of 338.2 — (166.4 — 32) = 1009.192 B.t.u. Evaporation of a pound of water from and at 212 deg. F., requires 970.4 B.t.u., and for the conditions stated the factor of evaporation is $1009.192 \div 970.4 = 1.0399$. The evaporation under actual conditions was $313,000 \div 57,535 = 5.44$ lb. of water per pound of coal and $313,000 \div (57,535 - 8678) = 6.406$ lb. of water per pound of combustible, so that the equivalent evaporation from and at 212 deg. F. was $5.44 \times 1.0399 = 5.657$ lb. of water per pound of coal and $6.406 \times 1.0399 = 6.662$ lb. of water per pound of combustible.

A boiler horsepower is equivalent to evaporation of 34.5 lb. of water from and at 212 deg. F. per hour, and therefore the evaporation developed was $\frac{313,000 \times 1.0399}{10 \times 34.5} =$ 943.44 boiler hp., which is $(943.44 - 930) \div 930 = 0.0144$, or about $1\frac{1}{2}$ per cent. greater than the rated capacity.

Lower Allowable Pressure Requires Larger Safety Valve—Two boilers are of the same dimensions throughout and each is provided with the same size of grate, kind of fuel and draft, and the temperature of feed water in each case is to be 200 deg. F. One of the boilers is allowed to carry a working pressure of 50 lb. gage and the other 150 lb. gage. Which should be provided with the larger safety valve? E. L.

The boiler that is allowed the lower pressure should be provided with the larger safety valve. From the identity of the boilers and settings, it is to be presumed that each will transmit the same amount of heat in generation of steam. A pound of steam at 50 lb. gage, or 65 lb. absolute, contains 1178.5 B.t.u., and for generation from feed water at 200 deg. F., each pound would receive 1178.5 — (200 — 32) = 1010.5 B.t.u. A pound of steam at 150 lb. gage, or 165 lb. absolute, contains 1195 B.t.u., and for conversion of the feed water into steam at this pressure each pound must receive from the boiler 1195 — (200 — 32) = 1027 B.t.u. Therefore, for the same heat generated by the furnace and transmitted by the boiler, there would be $\frac{1010,5}{1027}$, or about 98 per cent. as many pounds of steam generated at the higher pressure. Napier's approximate formula for the discharge of steam from a safety valve is: Flow in pounds per second = absolute pressure $\times$ area in square inches $\div$ 70; that is, the escape area required is directly as the weight and inversely as the absolute pressure, so that the safety valve for discharging steam at 165 lb. absolute would need to have only 98 per cent. of $\frac{65}{165}$, or about 40 per cent. as much area of opening as for discharging as much steam as would be generated at 65 lb. absolute for the same amount of heat transmitted by the boiler.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

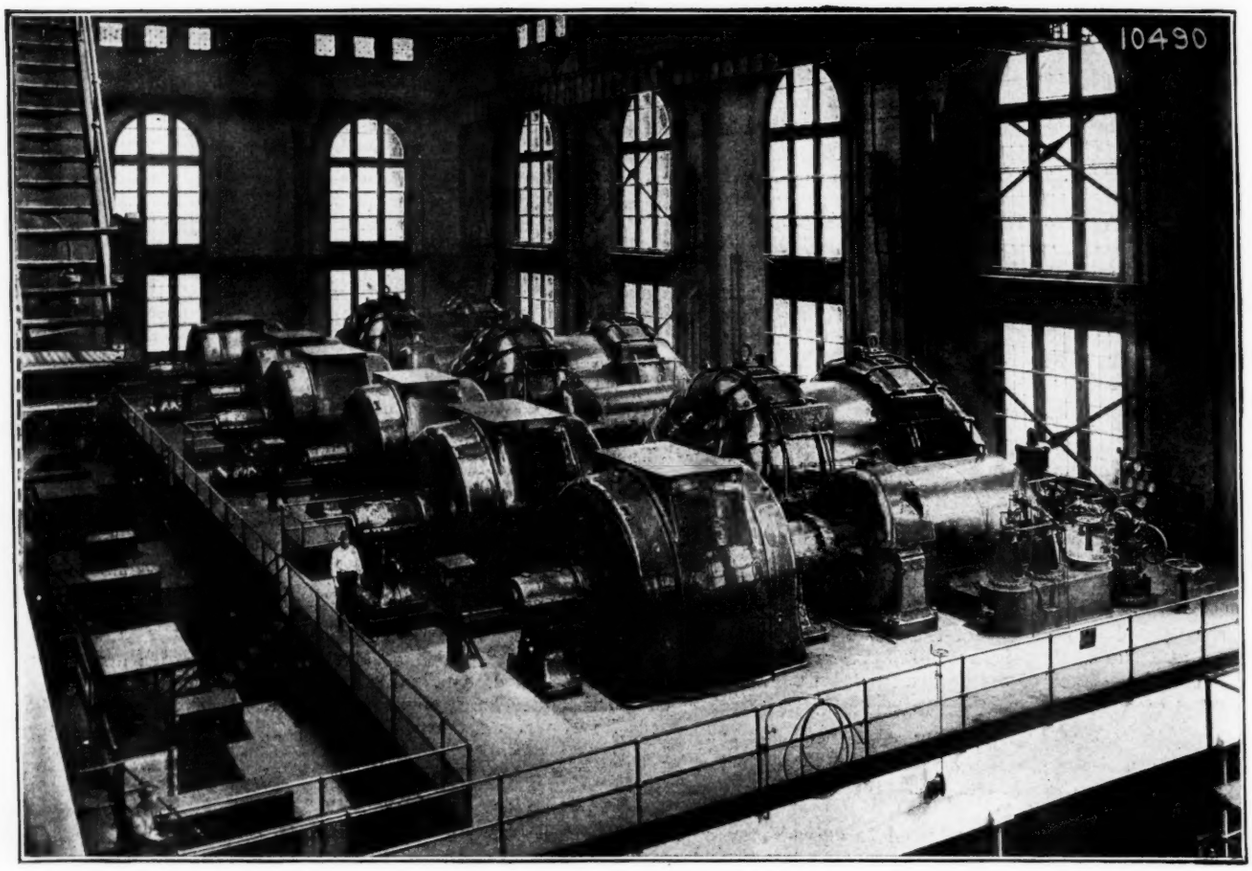


FIG. 1. THE 30-000-KW. COMPOUND TURBINES, INTERBOROUGH RAPID TRANSIT CO., NEW YORK

Notes on Large Steam-Turbine Design*

By J. F. JOHNSON
Engineer, Turbine Department, Westinghouse Electric and Manufacturing Company

The author discusses those factors that influence the determination of the size of steam turbines for modern power stations. He follows this with a valuable description of the operation of large reaction turbines which have been recently installed.

THE remarkable growth of the electric-power industry during recent years has been paralleled by an equally remarkable growth of steam-turbine-driven generating units. So rapid has this development been that frequently before the first machine of a new design was completed, another of materially greater capacity and higher efficiency was being designed.

While machines of 15,000-kw. capacity were put into operation as early as about 1908, their use did not become general until 1913; whereas today nearly every one of what may be called large generating stations has at least one unit of 30,000-kw. capacity or larger in service or on order.

Has this growth been natural, logical and healthy, or has it suffered temporarily from overstimulation which is destined to result in a relapse, or reversion to smaller sizes? If such reversion occurs, will it be the result of faulty engineering, born of overconfidence on the part of the builders of the apparatus or on the part of the users? That is, will be because units of necessary reliability and economy are not commercially obtainable, or because units of 30,000 kw. and larger are too large for the present and immediate future requirements of large power-generating stations?

In the following table is given roughly approximate figures showing for several districts, each included within a circle of about ten miles radius, the total capacity in kilowatts of generating units which will have to be installed by 1920, based upon an estimated increase of peak load of 8 per cent. each year and a surplus of generating capacity installed above peak load of 20 per cent.

District	Sum of Maximum Sustained Peak Load, All Companies, 1917	Total Capacities To Be Installed by 1920
New York	800,000	1,190,000
Chicago	400,000	596,000
Philadelphia	250,000	373,000
Buffalo and Niagara Falls	300,000	447,000
Detroit	155,000	231,000
Boston	155,000	231,000

In the selection of sizes of generating stations the choice of sizes of generating units is important because the number and sizes of units in a station of given capacity will materially affect the total cost of power generated. If the sizes of units be too small and the number too large, the cost per kilowatt of the station completed will be greater, the maintenance and operating expenses higher, the efficiency poorer and reliability at least no greater than if the proper sizes are used. On the other hand, if the units be too large, the cost per kilowatt installed may be too large because of the greater reserve or stand-by capacity required, and the efficiency may even be poorer by reason of the units operating at loads too far below their points of best efficiency.

*Abstract of a paper read before the Philadelphia Section, American Society of Mechanical Engineers.

Take for example, a district with a maximum peak requirement of 600,000 kw., which to insure proper reliability it is decided to generate in three stations of approximately equal sizes. We will assume that these stations will normally always operate in parallel with each other and that there will be one spare unit for each five in service during the peak. If 20,000-kw. units are used, there will be 30 operating and 6 spares, making a total of 36 units, 12 in each station. If 30,000-kw. units are used, there will be a total of 20 operating and 4 spares, making a total of 24 units, 8 in each station. If 40,000-kw. units are used, there will be a total of 15 operating and 3 spares, making a total of 18 units, 6 in each station. If 60,000-kw. units are used, there will be a total of 10 operating and 2 spares, making a total of 12, 4 in each station.

If, to remove from this consideration of ideal size of units conditions imposed by the design of the apparatus, it is assumed that irrespective of the size the reliability, efficiency and purchase price per kilowatt will be the same, it should be obvious without resorting to calculations that the 20,000-kw. size is too small and that best results are to be expected with either the 40,000- or 60,000-kw. sizes, because the installation costs, including buildings, foundations, piping and switching equipment, and operating costs, including maintenance, supplies and attendance, should be less per kilowatt; the efficiency higher because of the higher efficiency of the larger units, larger auxiliaries and smaller friction and radiation losses in the larger steam and water piping; and reliability greater because of the smaller number of operations of starting and stopping and cutting in and out of service of units necessary.

In so far as conditions affected by the design of units are concerned, it is quite generally appreciated that in sizes up to at least 30,000-kw. capacity, higher efficiency at the same cost per kilowatt is obtainable purely by reason of the larger size and still higher efficiency for a slight increase in cost per kilowatt, and it has been quite conclusively demonstrated that as high a degree of reliability is obtainable in these larger units as in the smaller ones. Fig. 10 shows the approximate relative steam consumption rate of units in sizes varying from 5000-kw. to 40,000-kw., all designed for the same cost per kilowatt.

While districts in which the peak requirements of any one operating company are as great as from 400,000 to 600,000-kw. are at the present time not numerous, there are many that will probably reach that stage before in-

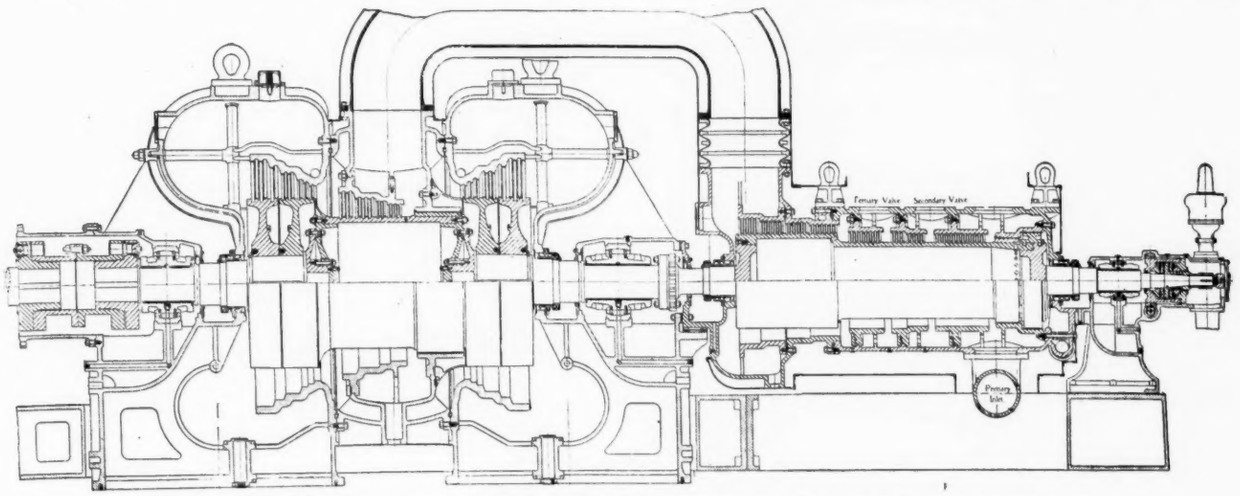


FIG. 2. CROSS-SECTION OF 30,000-KW. REACTION TURBINE, COMMONWEALTH EDISON CO.

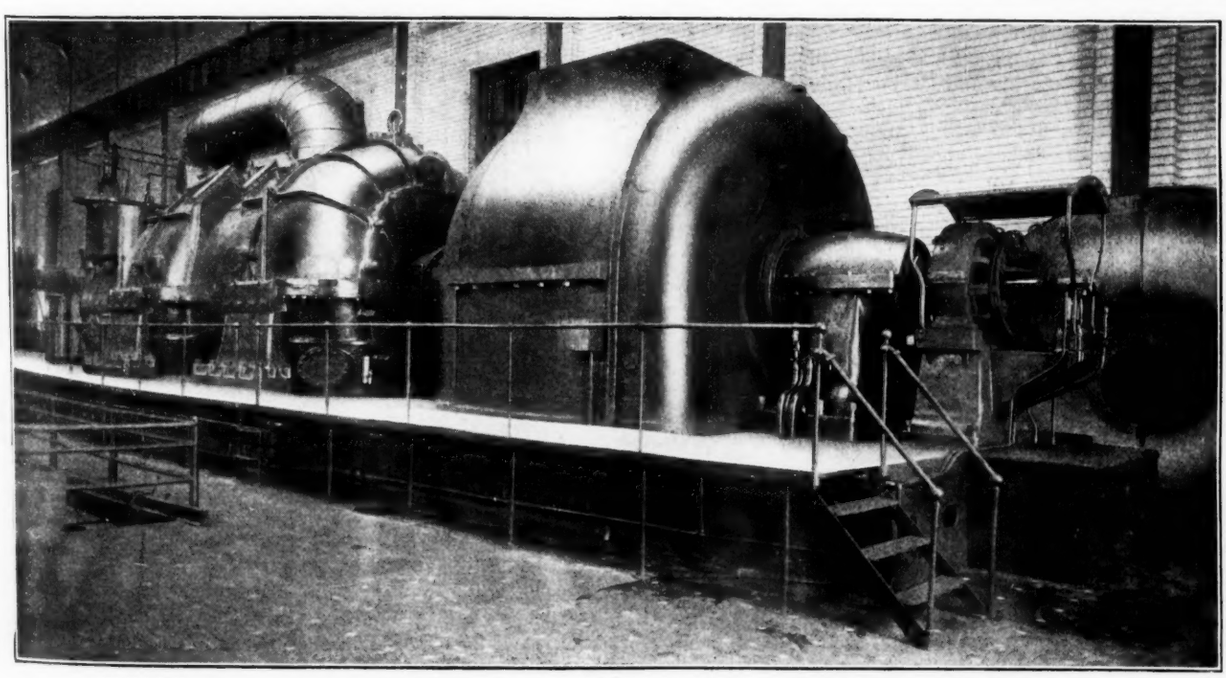


FIG. 3. GENERATOR END OF THE TANDEM COMPOUND MACHINE AT CHICAGO

stallations being made at this time will be expected to become obsolete. In these, units of the larger sizes should be introduced to replace smaller ones as they become obsolete and to take care of increasing requirements at such a rate as will effect the most economical production of power over the estimated period of usefulness of the machines installed. It will be in order here to make mention of the fact that numerous generating stations of about 200,000 kw.

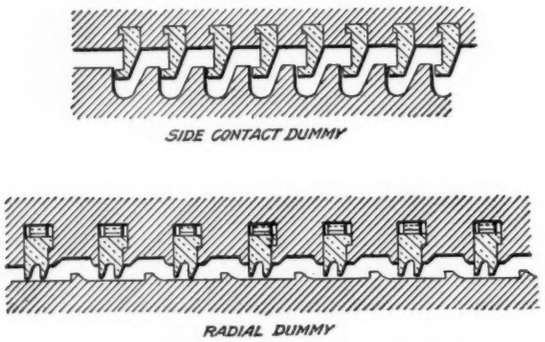


FIG. 4. SECTIONAL VIEWS OF DUMMIES

installed capacity, projected and designed by the ablest engineering talent in the country, are under construction and in operation, and units of 30,000 kw. and larger are being employed in them; also that stations of approximately 300,000 kw. installed capacity are being projected and will probably be built in the near future.

Appreciating the need of generating units of large capacities in the future growth of the electric-power industry, the engineering staff with which the writer is associated several years ago took up the work of designing such machines, assured themselves of their feasibility, and advocated their use. A number of them have now been in operation several years.

Up to the present a total of 14 units have been sold, varying in capacity from 30,000 to 70,000 kw. maximum. Of these 11 have been shipped, 10 are in service, and 7 have been in service for periods varying from approximately one to five years. The records of performance of these machines should emphatically remove any doubt as to the commercial possibility of units of large capacity, and satisfactorily prove that at least within limits not yet reached, increase in size need not impair reliability and may improve efficiency.

The first three of these units, which are exact duplicates, were sold to the Interborough Rapid Transit Co., of New York. They are of the two-cylinder cross-compound pure-reaction type, and designed for maximum reliability and efficiency. These units are shown in Fig. 1.

They are of 30,000 kw. maximum rating with point of highest efficiency at 25,000 kw., operating with 205 lb. steam pressure, 120 deg. F. superheat, 29 in. vacuum referred to 30 in., the high-pressure operating at 1500 r.p.m., and the low-pressure at 750 r.p.m. [A description of these units appears in *Power* for Apr. 20, 1915.]

The first one was put in service Dec. 30, 1914, the second in February and the third in August, 1915. Elaborate and exact steam-consumption tests were conducted on the first of these units by the purchaser. (See paper by H. G. Stott and W. S. Finlay, presented at May, 1916, meeting of New York Section of the A. S. M. E., also *Power* for May 23, 1916, p. 746.)

These units, since their installation, have been operating on an average of from sixteen to twenty hours per day, on fluctuating railway loads varying from 10,000 to 30,000 kw. With the first and third no troubles of any sort have been experienced, and they have been ready at all times for any service within their designed capacity except when out of service for regular periodic inspection or ordinary maintenance. On the second the labyrinth packing on the balance pistons of the high-pressure element has failed three times, requiring renewal of some parts. The cause of these failures was at first supposed to have been improper adjustment, but investigations following the third failure indicated excessive lost motion in the thrust bearing and heavy distortional stresses, caused by rigid bracing of the steam pipe near the turbine as the probable causes.

The fourth unit, placed in operation in the Northwest Station of the Commonwealth Edison Co., Chicago, in September, 1917, consists of a tandem-compound pure-reaction turbine, direct-connected to a single generator. It has a rating of 30,000 kw. with an additional overload capacity of 5000 kw. operating with 220 lb. steam pressure, 200 deg. F. superheat, and 29 in. vacuum, 1200 r.p.m. These are shown in Figs. 2 and 3.

A few hours after being put into service, subsequent to completion of erection, the labyrinth packing on the low-pressure element failed, due, we think, to buckling of the turbine cylinder, caused by rigid piping connections between the two surface condensers, which are bolted rigidly to the two exhaust openings on the turbine, preventing the condensers from translating with the turbine as its temperature increased. Temporary repairs were made locally and the unit put in service in about four weeks. It has been operating almost continuously since without trouble (except cracking of a copper expansion joint), carrying loads as high as 40,000 kw. In one instance it was kept on

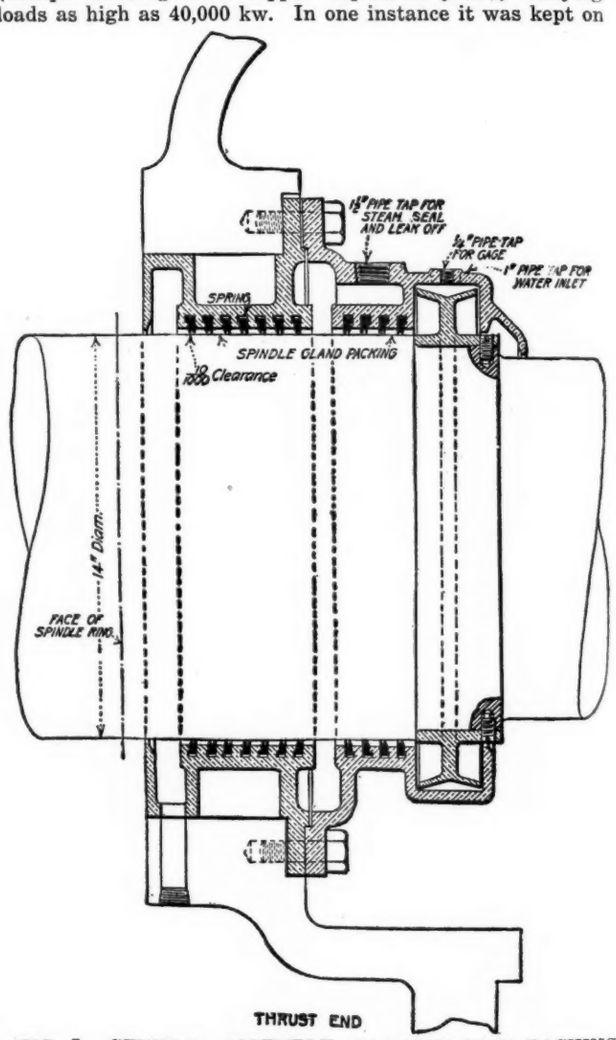


FIG. 5. GENERAL ASSEMBLY OF LABYRINTH PACKING

the line for 71 days, and then taken off only to clean the condenser. Material for making permanent repairs to the labyrinth packing was shipped to the station within a few months after the accident, but purchaser has not yet given permission to take the unit out of service long enough to install it. This packing in section is shown in Figs. 4 and 5.

The fifth unit, a 30,000-kw. pure-reaction single-cylinder machine, operating on 200 lb. steam pressure, 100 deg. superheat, 29 in. vacuum, was placed in operation in the

Gold Street Station of the Edison Electric Illuminating Co., of Brooklyn, in October, 1917. Owing to congestion in the shops and urgency of shipment, this turbine was not operated prior to shipment. The overspeed test was made after installation. No correction of balance was necessary, and with the exception of a few leaks in the oiling system and the breaking of a defective gear on the oil pump drive, no trouble has been experienced. It has been available for service at all times and has been operating approximately continuously except over Sundays and when necessary to clean the condensers, at average loads of approximately 23,000 kw., and peak loads as high as 32,000 kw.

The sixth unit, placed in service in December, 1917, in the Kent Avenue Station of Brooklyn Rapid Transit Co., is a duplicate of the fifth machine. Just after installation some rebalancing of both turbine and generator rotors was necessary. On Oct. 18, after having been in service about ten months, the Kingsbury thrust bearing overheated and wiped some, but did not damage any other part of the machine. When opened for inspection, it was found that the labyrinth packing strips, which were made of an aluminum alloy, were considerably corroded by the action of strong alkalies used at this plant for treating feed water; and two rows of blading in the high-pressure portion of the machine were found to have been damaged at some previous time, caused probably by foreign matter or a defective blade. This machine was in regular service up to Oct. 18, carrying maximum loads as high as 31,000 kw. and an average of 25,000 kw. The thrust bearing is shown in section in Fig. 6.

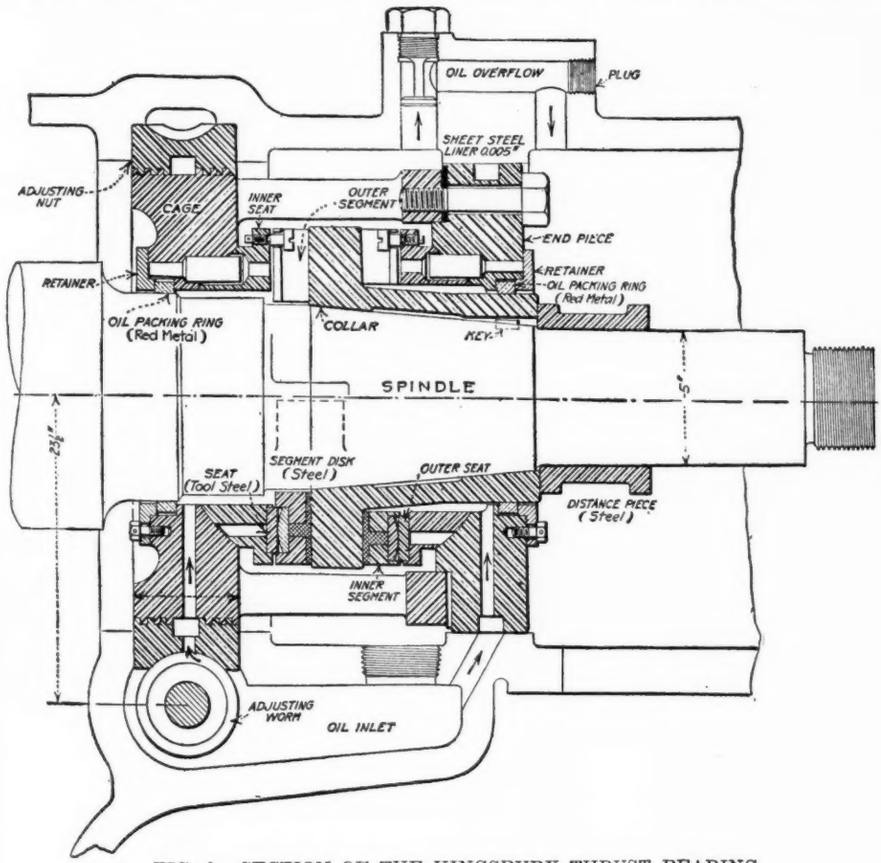


FIG. 6. SECTION OF THE KINGSBURY THRUST BEARING

The seventh unit is a 40,000-kw. 60-cycle cross-compound machine, installed in the Brunots Island Station of the Duquesne Light Co., and was placed in service in December, 1917. The high-pressure element of this machine operates at 1800 r.p.m. and the low-pressure at 1200 r.p.m. This unit has been in regular service carrying loads normally of from 30,000 to 40,000 kw. with peaks as high as 50,000 kw. On Feb. 18, while operating the machine to correct the balance of one of the generators, the main bearing at the coupling end of the high-pressure turbine burned out, apparently due to interruption of oil service to that bearing. This let the spindle down sufficiently to cause rather heavy blade rubs throughout the machine. The bearing was rebabbitted and the machine put back in service without any other work being done except rechecking the clearances and placing a balance weight on the spindle to correct for the weight rubbed off the blades. In July the generator was damaged by electrical trouble, and while this repair was being made, both elements of the turbine were dismantled. The high-pressure rotor was returned to the shops, the damaged blading replaced and rebalanced. New blading was also installed in the stator to restore original clearances and original efficiencies. Inspection of the low-pressure element revealed several broken blades which were defective and had slightly damaged the rest of the blading in those rows, requiring replacement of approximately 1½ rows of blading on each end of the machine. The eighth unit, practically a duplicate of the seventh, rated at 45,000 kw. maximum, was placed in service for the Narragansett Electric Light Co. in Providence in January, 1918. [For description with excellent drawings of this machine see *Power* for Aug. 27, 1918, p. 292.] In placing this machine in service the labyrinth packing on the high-pressure element was damaged, due to improper adjustment, which necessitated temporary repairs, keeping the machine out of service until about Mar. 1. Since then no trouble has been experienced except some distortion of the couplings caused by a series of violent short-circuits and some defective workmanship on the fitting of the coupling keys. Permanent repairs to the labyrinth packing have been made, and new coupling parts are to be installed in the near future. In the meantime the old parts are operating satisfactorily without any evidence of distress. This machine operates on loads as low as 5000 kw., and has carried a peak load of 50,000 kw. for periods of from four to five minutes. Longitudinal sections of the high- and the low-pressure elements are shown in Figs. 7 and 8.

The ninth unit is a 70,000-kw. three-cylinder cross-compound 25-cycle machine, installed for the Interborough Rapid Transit Co. in New York. The one low-pressure element was placed in service Apr. 18, 1918, operating on high-pressure steam. The high-pressure element was placed in service Aug. 21, operating in connection with the low-pressure already installed, and the second low-pressure element was placed in service Oct. 9. Some intermittent vibration trouble appeared on the first low-pressure machine, the cause for which was found to be lack of sufficient clearance on one of the spindle rings, causing distortion during expansion. After this was corrected no further trouble was experienced except the breaking of a few defective blades on the intermediate stage of the second low-pressure. This unit is equipped with an automatic control mechanism for cutting out of service, either automatically or manually, either element without disturbing the other two. These features have been given a thorough try-out, which in so far as a demonstration goes, has verified all expectations as to flexibility of this feature. In regular service it has carried loads as high as 55,000 kw. with swings up to 61,000 kw.

While these records do not all show 100 per cent. perfection, they do show that in not one instance has there been any evidence of inherent or basic defects in design or difficulties in construction or operation. Some troubles have been experienced, but these have all been of minor character, due to avoidable defects in detail design, construction, installation or operation; such as are experienced with new designs of any size or sort. It is significant that with one exception no important part of any one of these units has ever been returned to the works for replacement, alteration or repair. The high-pressure rotor of the Duquesne Light Co. unit was returned to the shops for checking for truth and reblading. While most of them have not been subjected to any accurate steam consumption tests, definite reductions in station coal consumption rates were effected by the installation.

The foregoing naturally leads to a consideration of some of the more important problems of large steam-turbine design and of their solutions. The successful practical design of a large turbine comprises many problems worthy of the highest engineering skill. Many conflicting factors must be most judiciously combined in order to secure the best evenly balanced design and one which will serve the purpose for which it was intended most usefully.

In this as in all other arts, carefully studied and accurately judged experience is the great teacher, and highest success is attained only after years of growth, adhering to the same basic design, the principles of which must be right and therefore susceptible to the highest development.

To begin with, the engineer must have a clear vision of his ideal, his turbine made perfect in every detail. This must be the standard toward which he constantly strives, deviating from it only as compelled to do so in compromising between conflicting factors. In this ideal, *reliability* and *general operative excellence* must stand out as the dominating characteristics, because above all things the machine must be dependable to deliver its rated capacity of kilowatts upon demand; second to this comes *efficiency*, because it must in competition with other units yield a profit for the owner; and third comes *cost*, because the unit must be salable in competition.

The first and perhaps greatest single problem is suggested in the theoretical design; namely, that of providing areas suitable to accommodate the enormous increase in volume of the steam while passing through the turbine. Steam supplied at the throttle at 250 lb. gage pressure and 150 deg. F. superheat enters the first stage at a pressure of about 255 lb. absolute and specific volume of 2.28 cu.ft. per lb. (allowing 10 lb. drop through the throttle and inlet valves). It leaves the last stage at 380 cu.ft. per lb. when 28½ in. vacuum is maintained by the condenser, and 550 cu.ft. per lb. when 29 in. is maintained; that is, the volume when exhausting to 28½ in. vacuum is 166⅔ times, and when exhausting to 29 in. is 241 times as large as it is at the entrance. This means that if the rate of steam flow is such as to require an 18-in. steam inlet pipe, and if its velocity were maintained the same through the exhaust as through the inlet pipe, the exhaust opening when expanding to 28½ in. vacuum would have to be 19 ft. 4 in. in diameter, and when expanding to 29 in. vacuum 23 ft. 4 in. in diameter; or if the mean diameter and exit angle of all the rows of blading be the same and the ratio of blade speed to steam speed be the same in each, thereby keeping the theoretical efficiency of all stages equal, and if these blade and steam speeds be so chosen as to fix the height of the blades in the first stage at one inch, the last row would have to be approximately 13 ft. 10½ in. if designed for 28½ in. vacuum, and 20 ft. 1 in. if it were designed for 29 in. vacuum.

A diagram has been prepared to show this enormous increase in volume and indicated thereon are the relative blade heights based on the assumption of the speeds being kept constant. The impracticability of adhering to such proportions in actual designs is obvious. See Fig. 9.

Here is where the combining of conflicting factors begins. In the first stages the areas and blade heights should be kept large to reduce the losses, and in the low-pressure stages they must be sacrificed on account of practicable limits of mechanical design. In single-cyclinder machines where the blading is all on the same spindle, the problem becomes doubly difficult.

The first determination is that of rotative speed, which is usually not difficult to make since the frequency of the generator restricts the permissible speeds to a few and these are rather widely separated. The limiting capacities at the various permissible rotative speeds for which generators can be built must also be considered, although at the present time the practicable limits of turbines and generators is reached at approximately the same capacities except in the case of single-phase generators. With these the limiting capacities are less than with polyphase generators.

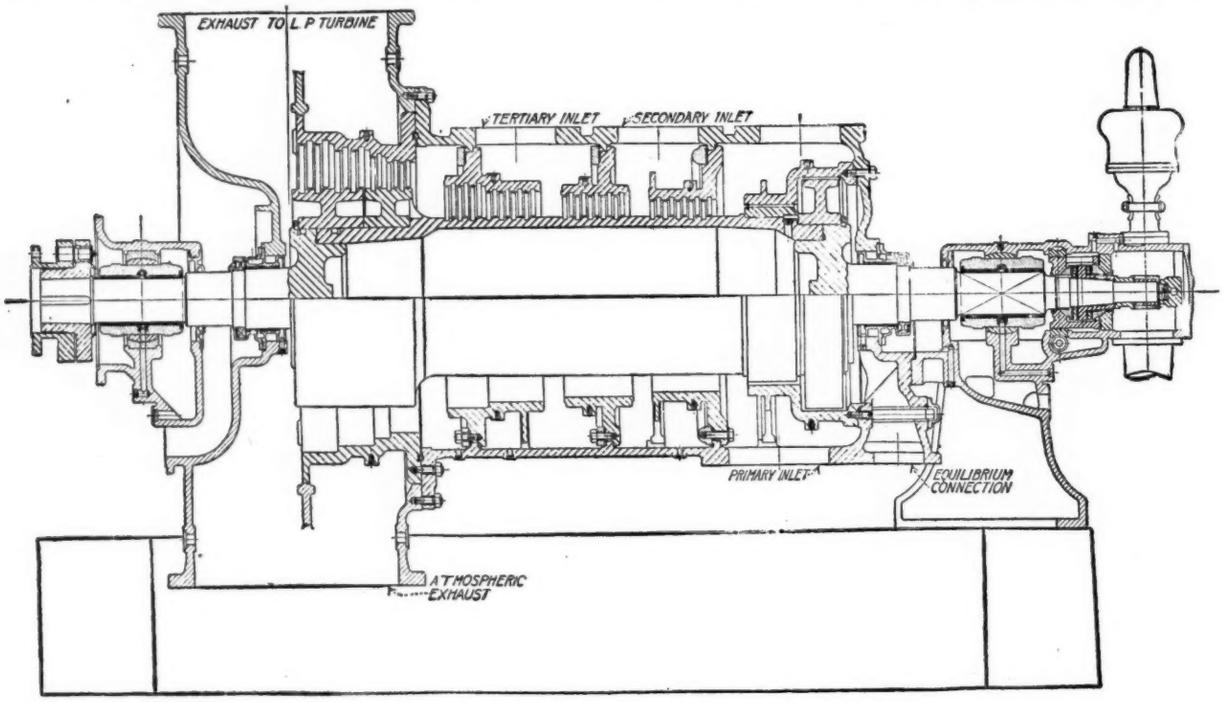


FIG. 7. LONGITUDINAL VIEW OF HIGH-PRESSURE ELEMENT, 45,000-KW. TURBINE

The chief factor in the selection of the rotative speed is the design of the last row of blades with reference to height, diameter and exit angle, because this is the most important stage in the whole turbine. In it the mechanical stresses and fatiguing effect of vibration, the B.t.u. drop and physical dimensions are all greatest. Consequently, upon it depend largely the reliability, efficiency and cost of the unit.

Here the temptation of reward in high efficiency without appropriate higher cost by departing from known reliable and conservative practice in the employment of materials and stresses is greatest, and the engineer must needs keep both eyes firmly fixed upon his ideal lest he be led astray by the alluring appeals of a daring commercialism. Here must be considered the alternatives of a higher rotative speed with the low-pressure stage made multiflow as against a slower rotative speed and single-flow construction.

The length of blades must not be excessive with reference to the diameter, not only because of the higher stresses reached, keeping the blade height within approximately one-fourth of the rotor diameter as a limit of good practice. The materials of which the rotor and blades are made will of course determine the safe stresses, and on account of the great import of safety and reliability in these parts, only good quality of plain, or 5 per cent. nickel low-carbon steels should be used because these are commercially common materials, uniform in quality and do not require sensitive heat treatments.

For rotors, cast or forged steel having a tensile strength of 70,000 lb., true elastic limit of 28,000 to 30,000 lb. and elongation of 18 per cent. in 2 in. may be stressed to 20,000 lb. per sq.in. and for blades 5 per cent. nickel steel having tensile strength of 85,000 lb. and true elastic limit of 35,000 lb., may be stressed to 25,000 lb., both at 20 per cent. overspeed. The stresses at normal operating speed will therefore be 13,900 and 17,350 lb. respectively, and the factor of safety against rupture approximately five.

Increasing the diameter not only permits increasing the blade height, but also the steam speed without materially

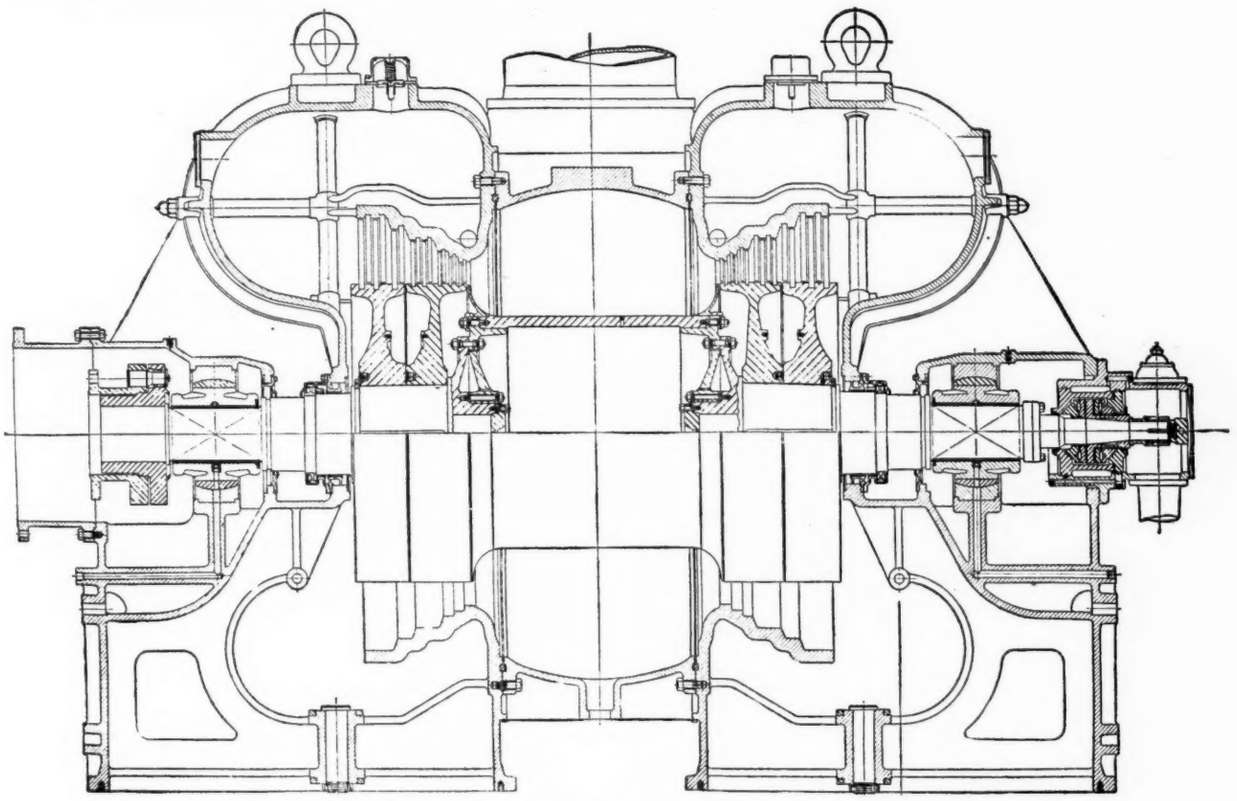


FIG. 8. LOW-PRESSURE ELEMENT OF THE 45,000-KW. TURBINE AT PROVIDENCE

in the blades and rotor, but also because the difference in velocity of the blades at their tips and at their roots, as well as the difference in blade spacing will, if too great, materially impair the efficiency.

On the other hand, if the area through the blades is too much restricted, the steam velocity will become too high and the bearing losses too great. If this restriction is carried to the extreme, the steam in passing through the last row of blades may even reach its critical velocity without expanding entirely down to the condenser pressure, in which event the remainder of the expansion takes place in the form of an explosion upon leaving the blade passages, and from it only a small percentage of the energy is recovered.

To secure the most satisfactory design for the last stages, and in order to permit the stresses or physical dimensions with the ever-present cost from becoming prohibitive, several compromise features are employed. The first of these consists of increasing the rotor diameter and blade heights, if necessary, until the safe limit of stress is affecting the efficiency, by reason of the increase in blade speed. There is, however, a slight falling off in efficiency with the higher speeds even though the ratio of blade to steam speed be kept practically constant because the actual velocity of the steam with reference to the blade being greater, the frictional losses will be greater.

The second compromise consists of increasing the steam-passage area through the blades by changing the blade shape. This change increases the angle between the direction of steam flow from the blade and the direction of the blade, and a slight impairment of efficiency results therefrom. However, this loss is slight compared to the gain from the higher ratio of blade speed to steam speed resulting from the increased area. This practice is standard on practically all condensing machines built for high vacuum.

The third compromise consists of permitting the steam speed to increase without a corresponding increase in blade speed, thereby decreasing the ratio of blade speed to steam speed, and increasing the leaving losses. This compromise

may properly be employed up to the point where the loss of efficiency will justify the increased expense of greater blade areas which may necessitate dropping to a lower rotative speed or employing multiple stages.

Two or more low-pressure stages in multiple in connection with a single high-pressure stage are used when the required areas cannot be obtained with a single stage at the rotative speed chosen, and when it is more feasible to employ multiple stages than a lower rotative speed.

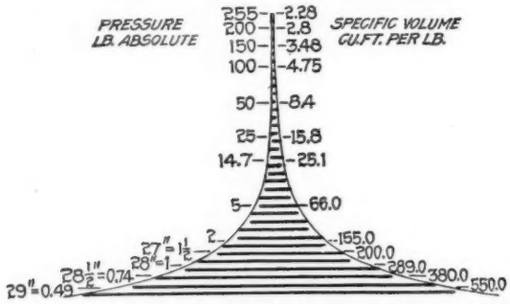


FIG. 9. INCREASE IN VOLUME OF STEAM FOR DIFFERENT VACUUMS AND RELATIVE BLADE LENGTHS REQUIRED

Other considerations favoring multiple stages are (1), reduced physical dimensions of the exhaust chambers, simplifying both the ribbing and bracing necessary to maintain the proper rigidity; and the cylinder-supporting structure, including foundations; and (2), limitations of shipping dimensions established by transportation companies.

The design of the higher stages usually involves only an equitable selection of diameters, blade speeds and steam speeds. Keeping these low results in low stresses and high efficiency, but large number of stages, and high cost; while keeping them high reduces the length, weight and cost, but increases the stresses and impairs the efficiency.

If the steam volumes in the first stages are relatively small for the rotative speed employed, as would be occasioned by the use of high steam pressure or low rating, a double-velocity-stage impulse element may often be employed to advantage, the advantages secured being reduction of length, increased diameter, reduced pressure and temperature inside the main cylinder and adaptability for varying overload capacity, but not increased efficiency nor decreased cost.

Having fixed the rotative speed to secure proper design of the low-pressure stages, and the diameters and steam speeds of the high-pressure stages to give the highest economy, the length of the rotor may become excessive, necessitating its division into two parts to maintain requisite reliability. These parts may be arranged either in tandem form, driving a single generator, or in cross-compound form driving two generators. When arranged cross-

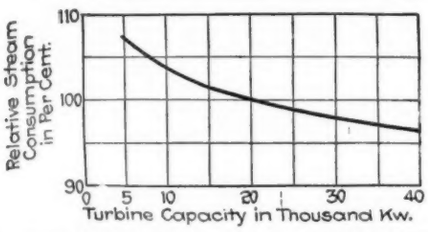


FIG. 10. RELATIVE STEAM CONSUMPTION OF UNITS OF FROM 5000 TO 40,000 KW. CAPACITY, ALL DESIGNED FOR SAME COST PER KILOWATT

compound, it will often be found advantageous to increase the rotative speed of the high-pressure element, thereby gaining reduced physical dimensions, weight and cost, without sacrifice of efficiency or reliability. The multicylinder construction is especially desirable in the employment of high steam pressures and superheats in that the high-pressure turbine structure is small and there is no danger of stress complications resulting from wide temperature differences and no transmission of heat through the cylinder walls from the high-pressure to low-pressure stages. It has a further advantage in these days of increasing steam conditions in that a unit may be designed for given steam conditions and later redesigned for materially higher conditions, the redesign being entirely carried out in the high-pressure element.

In units of 60,000 kw. or larger, the three-cylinder cross-compound construction employing one high-pressure and two low-pressure elements, possesses the advantages of high efficiency and reliability without employing excessively large structures and has greater flexibility than is possible with either of the other constructions. This flexibility, enabling the high-pressure element to operate with either low-pressure element, or either of the three elements to operate alone, admirably adapts it for use in systems not yet large enough to permit employing a single unit of so large capacity. These units may be provided with a control mechanism by means of which either of the elements may be taken out of service either automatically or manually, through operation of circuit-breakers or automatic stop governor, and the remaining ones will continue to operate, carrying loads up to the maximum ratings of their generators. The low-pressure elements, when operating on high-pressure steam direct, may be made to carry loads for short periods considerably in excess of the rated capacities of their generators.

In Pennsylvania there is a fire that has been burning continuously for sixty years. It started in a coal mine and spread to surrounding deposits. How much fuel it has wastefully consumed cannot be even approximately estimated. It is said that more than one million dollars has been expended in efforts to extinguish the fire, all in vain. Now another attempt is to be made. The plan is to strip the top of the mountain which overlies the burning section, remove veins of coal that lie in the path of the fire, and thus "starve" it. The area to be stripped is about a mile long and 400 yards wide. The stripping will have to be of an average depth of forty feet.—*Detroit News.*

Keep Coal out of the waste pile and waste out of the Coal Pile

OF the earth's abundance only those things that procreate are subject to increase. Fixed in the earth is the great storehouse of mineral wealth, and upon it we must depend for all time By no human skill may it be increased by so much as one tiny atom. The total amount is inwrought and immutable. Mine, either by surface operation or deep-driven incision, and instead of nourishing and curing the wound nature leaves it stark. Elsewhere and yet elsewhere must the stuff of life be taken out and carried away. Let us not waste this stuff Whether it be heat-giving, power-giving coal or something less essential to happiness let us save at every step The Pennsylvania Crusher Company intends to do its full share and seeks to work with those who are interested in

keeping coal out of the waste pile and waste out of the coal pile

FUEL-CONSERVATION WALL HANGER

An attractive wall hanger in two colors, about 10 by 12½ in., which is reproduced in miniature here, has been issued by the Pennsylvania Crusher Co., Stephen Girard Building, Philadelphia, Penn. It is intended for free distribution and anyone interested in fuel saving can obtain a copy on application to the company.

American Engineering Standards Committee

IN HIS address, "Engineering and Industrial Standardization," delivered at the Midwinter Convention of the American Institute of Electrical Engineers, Feb. 20, 1919, President Comfort A. Adams outlined the purpose and machinery of the American Engineering Standards Committee as follows:

At present the work of standardization is carried on by numerous organizations each in its own field and with its own machinery, usually through a standards committee. But the fields overlap and the machinery differs largely in the different organizations. In many cases the committees are made up of men who do not realize that a standard must be not only rational and technically correct, but also acceptable to all those interested in its manufacture and use. The mere promulgation of a standard by any society, however powerful, does not make it a real standard.

Moreover, the fields of the several organizations overlap in large degree; there is much duplication of effort and confusion of result, and many of the standards promulgated are practically useless.

Coöperation between two or more organizations has been tried, sometimes successfully, but there was no recognized machinery of coöperation, no standard procedure, and confusion still reigns.

To meet this need there has been recently created an American Engineering Standards Committee whose purpose, organization and method of operation are outlined below:

The American Engineering Standards Committee was formed by joint action of five national engineering societies (American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers and the American Society for Testing Materials) called the "Founder Societies," to meet a long-felt need of some available and satisfactory machinery for the development of engineering and industrial standards, by the operation of which duplication would be avoided and coöperation between all interested organizations and Government departments secured; so that when a standard or group of standards is developed it will be acceptable to all concerned and therefore a real American standard. Moreover, as international standardization develops, there is imperative need for an authoritative national body to deal with the corresponding foreign bodies. National Engineering Standards Committees are already in operation in England, Canada, France and Holland, and others will undoubtedly be organized in the near future.

The American Engineering Standards Committee machinery now proposed for the development of standards is made up as follows:

a. The committee proper or the "Main Committee," with three representatives from each of the five "Founder Societies" and three Government departments, whose functions are chiefly those of an organizing, coördinating and steering committee.

b. "Sectional Committees," one for each group of standards, with representatives from all organizations or Government departments vitally interested in that particular group of standards, whose function is to prepare the standards in question under the direction of the most vitally interested organization known as the "Sponsor Body."

c. The "Sponsor Body" or "Body" may be one of the Founder Societies, a Government department, or one of the "Coöperating Societies" or organizations.

d. Under "Coöperating Societies" it is intended to include all organizations interested in the production of standards and willing to coöperate.

The procedure is:

1. When the development of a particular group of standards is proposed, the main committee assigns the work to the appropriate organization as "sponsor," or if the situation seems to indicate that more than one organization is equally interested, to these organizations as "joint sponsor."

2. The sponsor then appoints the sectional committee subject to the approval of the main committee. The purpose of this approval is merely to assure the comprehensive representation of all the interests involved. Complete records of all interested organizations and of their standardization work and connection will be kept on file and properly classified in the office of the main committee. The main committee or its secretary will thus be able either promptly to suggest the proper representation to a sponsor on request or to approve or amplify the representation as provisionally proposed by the sponsor.

3. After a group of standards has been prepared and accepted by a sectional committee, it is submitted to the sponsor body for its approval and then to the main committee with a full report of its history. When approved by both the sponsor body and the main committee, the standards in question become American standards.

4. When the report of any sectional committee is being considered by the main committee, three members of that sectional committee are invited to sit with the Main committee to report, discuss and vote on the standards in question as if they were regular members of the committee. Thus each sectional committee, and therefore usually each sponsor body, will be represented on the main committee when standards in which they are interested are discussed.

5. The scrutiny of a standard by the main committee is to make sure that the proper procedure was pursued (that is, was prepared by a comprehensively representative sectional committee), that the vote of acceptance was nearly enough unanimous, and that the standard is consistent with other related standards. Consideration is also given to international relations; but the main committee is not supposed to pass upon the details, as it is obviously impossible for a moderate-sized workable committee to cover the details of all parts of the field.

6. After approval by the main committee the standard is published by the sponsor body with the statement that it has been approved by the American Engineering Standards Committee and labeled "American Standard," with the appropriate descriptive title.

Briefly summarized this procedure is as follows: Standard assigned by main committee to sponsor body; sponsor body appoints a thoroughly representative sectional committee, subject to approval of main committee; sectional committee prepares standard and submits to sponsor body, which then submits the standard with its approval to the main committee. The standard is then published by the sponsor body and labeled, "American Standard."

The machinery thus provides for absolutely comprehensive coöperation, eliminates overlapping and duplication of effort, and yet does not undesirably restrict the initiative of the several coöperating societies.

With proper support and the coöperation of all interested organizations, it should contribute largely to the industrial development of the country.

Moreover, it should be a potent factor in promoting international standardization and foreign commerce.

In the broad sense international standardization means a common industrial language and the removal of one of those barriers which tend to separate nations and to give rise to misunderstandings.

The more of these barriers we can remove, the more likely we are to attain that lasting peace which the world longs for.

Under a final agreement on the oil leasing bill more than 50,000,000 acres of Government-owned oil, gas, coal, phosphate and sodium lands in Western states and Alaska will be opened for development. The land will be subject to a royalty, which in the case of oil and gas will not be less than one-eighth of the gross value of the production.

Congress has authorized the expenditure of $100,000 for lignite investigations by the Bureau of Mines and a survey is being made to determine where the experimental plant shall be located.

Midwinter Convention of the American Institute of Electrical Engineers

The American Institute of Electrical Engineers held its seventh annual midwinter convention, Feb. 19, 20 and 21, in the Engineering Societies Building, New York City. The first session, Wednesday afternoon, was a joint meeting of the American Institute of Electrical Engineers and American Institute of Mining Engineers. Electric Welding was the subject discussed at this session, five papers being presented.

S. W. Miller presented a paper, "Path of Rupture in Steel Fusion Welds," in which he pointed out the results of a series of tests on welds made by various processes in different kinds of iron and steel. These tests consisted very largely of a photomicrograph study of both gas and electric welds subjected to bending after being polished and etched. In the paper are given 82 of these photomicrographs, some of them of 1200 diameters. The etching was done with a 2 per cent. solution of nitric acid in absolute alcohol and has been carried far enough to show the grain boundaries. The object of the etching was to locate the grain boundaries, therefore no attention was paid to the structure of the heavy etchings unless they were checked by normal etching with both picric and nitric acid.

The author expressed the opinion that in the present case it is difficult to describe what occurs during the testing, therefore he has given most of the information with photographs. The conclusion reached is that the first evidence of strain in any weld is at whatever visible defects may exist in the weld, such as films of oxide around the grains or around small particles of metal, as in electric welds. However, this is hard to prove by photographs. In electric welds the structure is usually more columnar than in gas welds. It would appear that the rapid cooling of electric welds is responsible for this and that the slower cooling of gas welds probably makes the grains more nearly equiaxed.

All brittle welds resemble one another in that the structure is more or less columnar and that they contain impurities. According to the usual understanding, during the solidification or cooling from high temperatures of a metal, impurities are rejected to the grain boundaries. The author is of the opinion from rough tests he has made that the brittleness in gas welds at least can be removed by heat treatment. However, he is not so sure about electric welds, since their heat treatment, at least in an ordinary way, does not remove the line structure; in many cases the lines lie either on or very close to the grain boundaries.

The quenching of electric welds appears to produce an entirely different structure; the grains lose their columnar nature and the lines disappear. It seems clear that the only way to account for the brittleness of welds is to assume that it is caused by films of material at the grain boundaries, the nature of these films differing in different welds.

While the author questions whether anything but circumstantial evidence can ever be adduced for his belief in the presence of the films, the facts are that, under welding conditions, very thin films which are visible do exist; and that with welds containing impurities, the breakage is always at the grain boundaries where it is known the impurities collect. So he sees no reason to doubt their existence and believes that they are responsible for the brittleness of such welds.

In a paper, "Micostructures of Iron Deposited by Electric Arc Welding," read by George F. Comstock, the author adds some further discussion on a paper, "Some Structures in Steel Fusion Welds," by S. W. Miller, presented before the American Institute of Mining Engineers, February, 1918. This paper is also a photomicrographic study of electric welds.

"Welding Mild Steel," a paper presented by H. M. Hobart, deals with investigations undertaken by the Welding Research Subcommittee of the Welding Committee of the Emergency Fleet Corporation. An abstract of this paper will appear in an early issue of *Power*.

A brief review was given of what had been done in substituting welding for riveting in ship construction, by S. V. Goodall in a paper, "Welding, a Process in Ship Construction." The author points out that the Welding Committee of the Emergency Fleet Corporation has found by actual experience that a labor saving of at least 60 per cent. has resulted from the substitution of arc welding for riveting on minor parts of ships where structural strength is of little concern. The conclusion is reached that the best line of approach appears to be to build up a staff of thoroughly skilled welders, to gain experience by the adoption of welding on minor parts, to proceed cautiously in the extension of the process to more important members, not to expect a great saving in time and cost immediately, but to persevere, not necessarily toward the rivetless ship, but toward a vessel in which the employment of both processes of riveting and welding is so adjusted that more riveting or more welding could be done only at greater cost.

O. H. Escholz, in a paper, "Fusion in Arc Welding," called attention to such characteristics as penetration and overlap, peculiar to the metallic-electrode arc-welding process, which facilitate visual inspection and discussed briefly the effect of arc length, welding procedure, electrode material, arc current and electrode diameter upon these characteristics. An abstract of this paper will be published in an early issue of *Power*.

Comfort A. Adams, president of the American Institute of Electrical Engineers, who presided at the meeting, gave a brief summary of the work done by the Welding Committee of the Emergency Fleet Corporation, of which he is chairman. The speaker told how ever 20 tons of steel plates had been used in making the welding tests of the research committee. He said that the advance made in electric welding during the last year had been as great as that of the preceding ten years and announced that a new welding organization is being started to continue the work begun by the welding committee and to carry on investigations necessary for the advancement of all classes of welding.

In discussing the various papers on welding, H. A. Horner spoke of the necessity of having skilled welders and told how those of the Emergency Fleet Corporation were instructed. Mr. Horner expressed the opinion that the outlook for producing skilled welders from the laboring classes were not very promising and that few exceptionally skilled welders were produced by the training given the class of men the Emergency Fleet Corporation had to instruct. The speaker said that the best welders are men of a very sensitive nature and that if conditions were not favorable for producing good welds they would stop work. To produce good welds the welder must concentrate all his attention upon his work and he cannot be expected to do satisfactory work if he has to dodge hot rivets.

W. L. Merrill took just the opposite view to what Mr. Horner expressed regarding training unskilled laborers to become skilled welders. He said this was not only possible but had already been done. Speaking on spot welding, Mr. Merrill said that it was always possible to tell the character of the weld by an inspection of the surface of the weld, and that two spot-welding machines, each weighing 6 tons, had been built and successfully tested in ship construction.

It was brought out in the discussion that a system was under development whereby the quality of any weld could be determined without destroying the weld.

The part of the discussion of greatest interest to power-plant engineers was that by H. R. Woodrow on electric welding something over 10 miles of high-pressure steam line. This discussion is published on page 322 of this issue.

On Wednesday evening Dr. John A. Brashear delivered an exceedingly interesting lecture, entitled "An Evening with the New Astronomy." The lecture was illustrated with lantern slides, many of them showing what it was possible to see through the large telescopes, to the development

of which Dr. Brashear has devoted a large part of his life. From the applause given the speaker by the audience that filled the auditorium, it was evident that they felt the doctor's efforts had not been in vain.

At the Thursday morning session President Comfort A. Adams addressed the meeting on "Engineering and Industrial Standardization." He discussed the importance of standardization and its dangers and indicated the comparative chaos that still reigns in most parts of the field of engineering and industrial standardization, not only in the standards themselves, but in the methods of creating them, and outlined the machinery proposed by the American Engineering Standards Committee to remedy this condition. The outline of the proposed machinery of the American Engineering Standards Committee is published in this issue on page 337.

After President Adams delivered his address two papers were presented: "The General Equation of the Electric-Circuit—III," by C. P. Steinmetz; and "Review of Work of Subcommittee on Wave-Shape Standard, of the Standards Committee," by H. S. Osborne.

Thursday afternoon was devoted to technical excursions to the Brooklyn Navy Yard, which approximately 200 members and guests visited; to the New York Edison Co.'s Waterside Station, the United Electric Light and Power Co.'s power station, the Interborough Rapid Transit Co.'s power station, the Electrical Testing Laboratories and the laboratories of Bell Telephone System.

A dinner-dance was held on Thursday evening at the Hotel Astor, which 375 members and their guests attended.

Two technical sessions were held on Friday. The morning session was held under the auspices of the Telephone and Telegraph Committee. Two papers were presented: "Aëro Telephony," by E. B. Croft and E. H. Colpitt, and "Theory of Transient Oscillations," by J. R. Carsons. The afternoon session was held under the auspices of the Electrophysics Committee. Three papers were presented at this session: "Ionization of Occluded Gases in High-Tension Insulations," by G. B. Shanklin and J. J. Matson; "The Dielectric Strength of Air Films Entrapped in Solid Insulation," by F. Dubsky, and "Abnormal Voltages in Transformers," by L. F. Blume and A. H. Boyajian.

The average attendance at the meetings was large and the convention closed with a total registration of 1001.

Illinois Chief Engineers Meet at Dunning

SINCE the recent consolidation effected by the present Governor under the Civil Administrative Code, the various state institutions of Illinois are tied more closely together and are under common supervision. All mechanical work, including operation, maintenance, repair and new construction is subject to the supervision of Fred J. Postel, a state officer bearing the title of supervising engineer. The chief engineers of the various institutions, having charge of mechanical work, are now, in a way, units of the organization, and as there are many operating features of common interest, they were called together at state expense to hold their first annual meeting at Dunning on Feb. 14 and 15. An interesting program had been prepared, there was lively discussion on topics pertaining to the work, and in one of the power plants of the institution demonstrations of boiler-room instruments including draft and CO_2 equipment and a recording pyrometer, were made. Twenty-three institutions under the Department of Public Welfare and five normal-school plants were represented. The attendance exceeded forty and the meeting was such a decided success that in all probability it will be made an annual event.

Acting as chairman, Fred J. Postel first called upon the director of the Department of Public Welfare, Charles H. Thorne, who greeted engineers and spoke of the value to be derived from such a gathering. Mr. Thorne was a great believer in placing the engineer where he belonged, at the head of the mechanical equipment, giving him full charge in order that he will take pride in his work, assume the responsibility and receive the recognition that is due him.

Joseph Harrington, formerly administrative engineer for Illinois, United States Fuel Administration, introduced an excellent talk on "Boiler Room Operation" by commending highly the attitude toward engineers Mr. Thorne was trying to develop. The engineer was coming into his own. The experience of last winter had opened the eyes of the public to his importance and a realization that his work calls for ability, resourcefulness and sound judgment.

Upon the assumption that the speaker were called in to make a report on the power plant of a state institution, he would first want to know the over-all efficiency, measured by the coal per kilowatt-hour, or if current was not generated, by the pounds of steam per pound of coal. Coal-weighing equipment then was the first essential. It is necessary to know the amount of coal used in each day's run and if done right the coal to each boiler should be weighed, so that any variation in economy might be traced accurately to the source.

How much steam is made with the coal is the next question. Its solution calls for a steam-flow meter. Feed-water weighing equipment would answer the purpose, but, owing to the various leaks from the boiler, the records would not give accurately the steam delivered to the mains. The installation of both meters is preferable as one tends to check the other.

With the two fundamental items determined, the next step is to record these data in a simple and comprehensive log, so that the figures can be analyzed and comparison made with past performance. Division should be made between the boiler and engine rooms so that variations in efficiency can be traced to the proper department and corrective measures applied.

To analyze boiler-room conditions, start with the coal. Its heat value should be known. If it is not practical to test each carload received, the origin of the coal can be determined and from data available a close approximation made of the heat value and the ash content. Then determine the rate of combustion per square foot of grate area. The amount of coal that can be burned economically per unit of draft is definitely fixed. Limitations of each furnace should be recognized unless it was desired to force the furnace at a loss of efficiency by passing fixed carbon to the ashpit. About 7 lb. of air per pound of carbon was all that could be forced through the fuel bed. Unless the balance needed were admitted over the fire or around the grate, it would have to be supplied mechanically.

Excess air is determined by the gas analyzer. CO_2 readings are the best indications of furnace efficiency available. It is a nice thing to have a CO_2 recorder on each boiler or at least one instrument in the plant that could be shifted from one boiler to the other. A recording instrument is needed, as the conditions in a furnace constantly vary. Where such an instrument is not practical the speaker advocated a gas sampling tank on each boiler that would draw a continuous sample and hold it for the hand analyzer.

Hydrocarbon losses were not determined by the Orsat. Heat balance tests showed that the difference between clean and smoky operation ranged from 3 to 5 per cent., the hydrocarbon rather than the carbon loss being responsible. Insufficient furnace volume was usually responsible. An increase in flame travel would better conditions. In the old days boilers of the B. & W. type were set with the bottom of the front header 4 to 6 ft. above the floor. The furnaces were always smoky and efficiencies ranged from 55 to 60 per cent. Today boilers are set 12 ft. above the floor and for heavy loads 15 ft. is not too much. The furnace should be proportioned so that the flame does not reach the tubes. A cubical content of 12 cu.ft. per square foot of grate area, as compared to 6 cu.ft., the old standard, is not too much. With powdered coal volumes of 30 cu.ft. per square foot of grate have been reached, so that the furnace was as large as the boiler itself. Securing the

proper furnace volume is only half the problem. To get the necessary flame travel the height vertically must be considered. If the boilers cannot be raised, a dutch oven is the next best thing to secure length of flame travel.

The loss from unclean heating surface might easily prove serious. There were two sides; on one soot collected and on the other, scale. Excessive loss from either was readily preventable. As the loss due to scale increases as the square root of the thickness, the first thin layer does the greatest damage. The speaker was not a believer in boiler compounds. The scale-forming matter should be precipitated before the water reached the boiler. A water-purification system always paid. To prevent scale formation in the boiler was entirely feasible and economical.

Soot was one of the finest insulators known and allowing it to collect might be compared to wrapping the tubes with asbestos paper. For its removal the speaker liked to see mechanical blowers rather than the steam lance; for what the operator can do easily, he will do more readily. A rise of 25 deg. in the flue-gas temperature means approximately a loss of 1 per cent. in efficiency.

For the average six-boiler plant the instruments considered essential were a coal scale, steam-flow meter, gas-sampling tank and Orsat, flue-gas temperature recorder and a draft gage on the furnace and uptake. An operator could get by without more elaborate equipment, although there were refinements that might prove desirable.

In the discussion the accuracy of the steam-flow meter was questioned. More confidence was placed in the feed-water meter. The use of rain water and distilled water for makeup and the causes of pitting were discussed.

Oil carried over with the exhaust steam into a vacuum heating system and thence back to the boilers was a trouble that had been experienced. Due to the vacuum the oil had volatilized and got past the separator. The use of oil that did not volatilize readily and the insertion of a valve on the supply line that maintained pressure on the separator relieved the trouble.

On the basis that the appropriation for instruments was limited, it was Mr. Harrington's contention in reply to a question as to what instruments were most essential, that the coal must be weighed and the water measured.

Formation of slag on the lower tubes of a water-tube boiler had been prevented by the application of graphite and the use of a hand lance in addition to the mechanical blower. Reference was made to the perfection of mechanical elements to take care of the slag. Increasing the width of the throat between the end of the arch and the bridge-wall had lessened the slag trouble by reducing the velocity of the gases.

In removing soot excellent results had been obtained by the use of salt. The salt should be absolutely dry and not too coarse and should be placed on the hottest part of the fire. Tubes had been used to blow it to the proper location in the furnace. In one case it had been used in conjunction with a mechanical blower, with good results.

The use of a damper regulator that threw the damper fully off or on was not favored as it was seldom that the fuel bed was in a right condition for either extreme. A damper regulator that floated with the demand for steam was the better type to employ.

Friday Afternoon Session

At the afternoon session Prof. H. H. Stoek, of the University of Illinois, talked on coal storage and some of the things that had been discovered in a study of over 100 fires during the past season. Coal should be stored as near as possible to the point where it is to be used. The mines, the railways and the consumers should share the expense of storage as each is benefited thereby. From the storage of coal there is very little lost in heat value.

As to the kind of coal that can be stored safely, almost any bituminous coal under certain conditions will give trouble from spontaneous combustion. This trouble depends not so much on the coal itself as the size and the way in which it is stored. Most of the trouble from fires develops from run-of-mine coal, a mixture of fine and coarse particles. The finer the coal the greater the area exposed to the air and the greater the oxidation. With the coarse coal on the outside of the pile as it usually is, allowing air to get to the fine dust at the center, trouble is almost sure to develop. Lump or sized coal that is clean and does not contain much fine coal can be stored safely. Screenings have been stored by keeping the pile compact and pressed down to exclude the air. In over 100 fires in Chicago that have been studied during the past season, 55 per cent. were in mine-run coal and 33 per cent. in screenings. It did not seem to make any difference whether the piles were under cover or in the open, as the division on this basis was exactly even.

There were two ways to cool to prevent spontaneous combustion. One was to ventilate the pile thoroughly, supplying enough air to carry off the heat and the other was to admit no air at all, so that there could be no oxidation. The latter condition might be obtained by storing under water or in finely packed piles. One of the safety rules for storage was to limit the height of the pile to 8 or 10 ft. The temperature of the piles should be watched closely and when it reached 150 deg. preparations should be made to move it.

Pyramid piling usually brought the big lumps to the bottom and the sides, and the fine coal to the center and top. This was the worst condition possible, as air was readily admitted through the coarse coal and fires started readily at the junction point between the fine and coarse coal. If it is necessary to store mixed coal it should be piled in even layers.

In the discussion following it was brought out that fires were more likely to develop in coal that was brought in wet. In putting out fires a brine solution seemed to be more effective than water.

Prof. S. S. Parr, also from the University of Illinois, made a plea for uniform sampling of coal. He distributed printed instructions on equipment to use and method of sampling.

In the evening F. D. Whipp, fiscal supervisor, gave an interesting talk on state institutions, showing the activities and giving statistics on the cost of operation. The National Tube Company's reel on the manufacture of iron and steel pipe, showing the progress from the ore in the ground to the finished products, was also presented.

Saturday Morning's Session

On Saturday morning F. J. McCullough, assistant supervising engineer, gave an interesting talk on the leaks and wastes in state institutions that should be stopped. In his opinion the leaks and wastes were better indications of an engineer's ability than an examination.

The remainder of the day was taken up by discussion of operating problems. The utilization of waste heat in tunnels was recommended. The engineers were advised to allow the air for one or two buildings to flow through the tunnels and take up the heat that was radiated from the steam and hot-water piping. More attention should be paid to fresh air in the buildings, and to keep down the power required by the fans in cold weather part of the air should be recirculated. Vacuum heating systems could be laid out so that the returns would almost come back by themselves to the plant. The vacuum should not exceed 6 to 8 in. at the pump, giving about 3 or 4 in. at the building. A higher vacuum was disadvantageous as it would cause more leakage of air into the system and add to the work of the pump. It was pointed out that an oil separator should have at least 6 ft. of straight pipe ahead of it and a run of 10 ft. was better practice.

In two or three institutions in the domestic hot-water system an open heater had been substituted for a closed heater and the water circulated by means of a pump. The open heater was much easier to clean and as the steam from the pump was exhausted into the heater, there was very little loss. Some trouble had developed from scale forming in the pump.

By properly regulating the humidity, considerable saving could be effected in the steam required for heating. One of the simplest and most inexpensive methods was to introduce a steam jet in the air supply to the building when the indirect system of heating was employed, and in the case of direct radiation, to introduce a pet-cock in the riser near the ceiling of the various rooms.

Furnace Fractures While Bulge Is Being Forced Back

The report of the Manchester Steam Users' Association for 1917-18 contains an account of furnace fracture during the process of setting back a bulge that had formed. Usually, if a bulge is slight, it is forced back cold; but if it is deep, it is heated, driven back and finished off cold. In the instance referred to, a bulge had been set back and was being finished off cold, when suddenly a piece of metal about 10 in. in diameter broke out of the furnace plate. The condition at the edges of the break left no doubt that the fracture was instantaneous.

In explanation of this action, it is pointed out that wrought iron and mild steel have a common critical temperature, usually called blue heat, at which the metal is in a rotten condition and usually breaks if bent. If the bending is stopped before either breakage or cracks occur and the sample is laid aside for a short time and the bending is then continued, a fracture is almost certain to occur.

In the light of this explanation, the accident to the furnace plate is understandable. The center of the bulge was heated red hot for the setting-back operation, and there was a circular zone in which the metal was at a blue heat. The operation was successful, but the next day it was thought that improvement could be made and the ram pressure was again put on, this time on the cold plate, with the result that fracture occurred along the line of the blue-hot zone. The inference is that if a bulge is heated when being forced back, it should be reheated after the operation is finished.

Compromise on the Administration Water Power Bill

After what appeared to be an almost hopeless deadlock, the House and Senate conferees on the Administration water-power bill a few days ago reached a compromise agreement, which provides that the administration of water powers shall be vested in a commission composed of the Secretaries of War, Interior and Agriculture, who will be authorized to grant fifty-year permits for the use of water power. One of the principal points of disagreement was the recapture clause, the House committee insisting on the payment of the net investment, while the Senate stood out for payment on the basis of fair value. The recapture clause in the compromise bill provides that the Government upon expiration of the lease may take over the property by payment of an amount equal to the net investment provided this sum does not exceed the fair cash value.

The question of compensation to be paid the Government for the privilege of the grant was another matter of controversy, but now this matter is to be left in the hands of the commission.

It was hoped that the amended bill would reach the floor of the House and the Senate in the closing days of the session, and it is possible, although not altogether certain, that the bill may be passed before final adjournment.

Study the work you are doing. When a man gets it into his head that there is a right way and wrong way to handle every job, he has taken the first step toward making his work interesting.

Personal

W. G. Burrell, who has been in the employ of the Wellman-Seaver-Morgan Co. for the last 21 years, was elected second vice president of the company at its recent annual stockholders' meeting.

H. P. Rust, formerly with Viele, Blackwell & Buck, engineers, New York, and until recently with the engineers of the Canadian army, has accepted an appointment with Wm. Cramp & Sons Ship and Engine Building Co., Philadelphia, Penn., as engineer of plant.

W. S. Quigley, president of the Quigley Furnace Specialties Co., Inc., sailed for Liverpool on Feb. 15, for the purpose of further developing European connections of his company. He will spend several weeks in England, France and Italy and visit the plants installing the Quigley system for preparing and burning pulverized coal and lignite.

Lieut. A. G. Kessler, U. S. N. R. F., who for the last six months has been in charge of the gun division of the Bureau of Ordnance, Navy Department, has been released from active duty in the Naval service and has become vice-president of the General Ordnance Co., Derby, Conn., and of the National Tractor Co., Cedar Rapids, Iowa, in charge of purchasing and production at both plants. Mr. Kessler was formerly general manager of the Lakeside Forge Co., Erie, Penn. The New York offices of the National Tractor Co. are at 512 Fifth Ave.

R. E. S. Geare has been elected president of the Mid West Manufacturing Co., recently incorporated. Mr. Geare is well known to the construction and power plant field in Chicago and the Middle West because of his active representation of the T. L. Smith Co., Manistee Iron Work. Co., Geare & Co., and others, which work he will still continue. The Mid West Manufacturing Co. has located its factory in Chicago, with general offices in the Old Colony Building. It has acquired the sales and manufacturing rights of the "Continental" chain-grate stoker from the Manistee Iron Works, and the "Chaingrip" pipe vise and tools from the Gerolo Manufacturing Co. In addition to this the manufacture of special machines, tools and dies; rebuilding of construction and power plant machinery together with the installation of such machinery will constitute an important part of the new company's activity.

Engineering Affairs

The American Association of Engineers will hold its annual convention at the Hotel LaSalle, Chicago, May 13-14.

The American Institute of Electrical Engineers will hold its three hundred and forty-eighth meeting in Boston, Mass., Mar. 14.

The National Electric Light Association will hold its annual convention at Atlantic City during the week beginning May 19, and plans are now being perfected for making it all that the big pre-war meetings were. The customary exhibition, which has not been held since 1916, will be one of the big features at the coming convention.

The Manufacturers Aircraft Association, Inc., will hold its first aëronautical exposition in Madison Square Garden and the 69th Regiment Armory, New York City, March 1-15. Every phase of the industry will be represented and the exposition will have a distinctly international character. It is expected that the Division of Military Aëronautics will have available for display an interesting collection of war trophies; and both the Navy and Army have prepared comprehensive exhibits of mechanical appliances and scientific instruments called into being by the remarkable development of aërial navigation during the war.

Miscellaneous News

The New Jersey Board of Boiler Rules will hold a public hearing at the State House, Trenton, N. J., on Thursday, Mar. 20 at 2 p. m. for final consideration of adoption of the recently revised A. S. M. E. Boiler Code covering "New Installations, Part I, Section I, Power Boilers."

Business Items

The Dearborn Chemical Co.'s Indianapolis (Ind.) office is now back at 312 Traction Terminal Building.

The Pulverized Fuel Equipment Corp. has recently been organized for the purpose of taking over the business of the Locomotive Pulverized Fuel Co., and to broaden the activities of the latter to cover the central power station, metallurgical and industrial fields. The head offices are at 30 Church St., New York City, with Canadian office in the Transportation Building, Montreal.

Trade Catalogs

The Chas. A. Schieren Co., New York City, has issued a new Price List which differentiates the various brands of Schieren beltings by markings, grades and weights, and enables the buyer to select a belting to meet his specifications.

The Green Fuel Economizer Co., Beacon, N. Y., has issued a 63-page Bulletin No. 151, illustrating and telling all about "Green's" economizers. A catalog of useful information for all who have economizers in their charge.

The Chas. A. Schieren Co., New York City, has issued an attractive booklet, with artistic colored illustrations on "The Story of Schieren Beltings." The business of tanning hides and manufacturing the leather into belting is treated simply and fully, in a way that any layman can understand.

Modern Methods of Ash Disposal. American Steam Conveyor Corp., Chicago. Pages, 160, 7½ x 10 in. Fully describes the four principal classes of ash-disposal systems, giving the advantages and disadvantages of all the various methods. Also illustrates typical installations and designs.

The Graton & Knight Manufacturing Co., Worcester, Mass., has gotten out a very finely illustrated catalog in two colors, showing the different processes of belt making from the receiving of the hide right through to the finished belt. It consists of 124 pages with a special three-page insert of the factory. It not only illustrates and describes the different products made by this company, but shows what can be accomplished for the manufacture of high-grade leather belting and leather specialties. The belting section fully explains the characteristic qualities, the particular differences and the capabilities of the different brands of belting. It also embodies mechanical rules, tables and other information that should be of value in determining the most efficient belt for any drive or in assisting with other transmission problems. The Graton & Knight Manufacturing Co. will gladly furnish anyone interested with a copy of this catalog.

New Construction

PROPOSED WORK

Vt., Bristol—The Hortonia Power Co., Brandon, plans to build an extension to its hydro-power plant here. I. M. Forst, Gryphon Bldg., Rutland, Gen. Mgr.

Mass., Holyoke—The School Board plans to install a steam heating system in the 2-story school building which it plans to build. Total estimated cost, $275,000. G. P. B. Alderman & Co., 437 High St., Arch.

Mass., South Boston—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., will receive bids until Mar. 18 for installing 2 air compressors at the Navy Yard here. Schedule No. 3788.

R. I., Providence—The Board of Contract & Supply is having plans prepared by J. H. Gainer, Engr., City Hall, for the construction of a central heating plant.

Conn., Norwalk—The Norwalk Realty & Improvement Co., c/o M. N. Mayehoff, 31 West Ave., plans to install a steam heating system in the hotel which it plans to build on Wall St., on the site of Old Royal James Inn. Total estimated cost, $100,000. G. F. Shepard, 14 Kilby St., Boston, Mass., Arch.

N. Y., Mohawk—W. W. Wotherspoon, State Supt. of Public Works, Capitol, Albany, is having plans prepared for the construction of a hydraulic power plant here.

N. Y., New Rifton—The Hudson Power Corp., c/o Kingston Gas & Electric Co., Kingston, has had plans prepared for the construction of a power plant on the Walkill River, here. J. G. White Engineering Corp., 43 Exchange Place, New York City, Engr.

N. Y., New York—The Swartout Realty Co., c/o Ames & Co., 26 West 31st St., will install a steam heating system in the 2-story, 100 x 171 ft. garage which it plans to build on Lenox Ave. between 110th and 111th St. Total estimated cost, $200,000. B. M. Levitan, 7 West 45th St., Arch.

N. Y., Syracuse—The Department of Education will install a steam heating system in the 3-story, 100 x 150 ft. school which it plans to build on Madison and Walnut Ave. Total estimated cost, $230,000.

N. Y., Tonawanda—The Republic Light, Heat & Power Co. plans to build an electric-lighting-plant here.

N. Y., Wards Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install an electric conduit and switchboard here. Estimated cost, $7500.

N. Y., Watervliet—The Ludlum Steel Co., Spring St., will build a 1-story boiler house.

N. Y., Wellsville—The Pure Carbon Co. plans to build a boiler house here.

Penn., Bethlehem—J. Osborne Hunt, Arch., 114 North Montgomery St., Trenton, N. J., will receive bids about May 1 for the construction of a 2-story, 60 x 200 ft. factory and a 1-story, 50 x 75 ft. power plant for the Travelers Tire & Rubber Co., 819 North Broad St., Philadelphia. Estimated cost, $500,000. Guy DeLee Rigandiere, Pres.

Penn., Honesdale—The Consolidated Heat, Light & Power Co., 110 7th St., plans to build an electric power plant here. Estimated cost, $50,000.

Penn., Meadville—The Meadville Malleable Iron Co., Kerrtown St., plans to build a 1-story, 45 x 50 ft. power plant. Estimated cost, $10,000.

Penn., Oil City—The city plans to build an addition to the boiler house. Estimated cost, $45,000. W. W. Holt, City Clk.

Penn., Philadelphia — The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install pumping equipment in the Naval Base, here. Specification No. 3816.

Penn., Philadelphia—Clark & Craighead, 1736 North Broad St., will install a steam heating system in the 2-story, 100 x 200 ft. garage, store and office building which will be built here. Total estimated cost, $150,000.

Penn., Philadelphia—The Philadelphia Electric Co., 1000 Chestnut St., plans to improve its plant. A. J. DeCamp, Mgr.

Penn., York Haven—The York Haven Water & Power Co. has retained Gannett, Seelye & Fleming, Engrs., 204 Locust St., Harrisburg, to make investigations and submit report for improving and enlarging the 20,000 hp. hydro-electric power plant. W. L. Mann, Gen. Mgr.

D. C., Washington—The Bureau of Supplies & Accounts, Navy Department, will receive bids until Mar. 18 for installing a 40-hp. motor and controller at the Navy Yard here. Specification No. 3787.

Ala., Union Springs—The city voted in favor of a $10,000 bond issue for improvements to its electric-light plant. Address the Mayor.

Ohio, Alliance—The city plans an election March 18 to vote on a $200,000 bond issue for the construction of an electric-light and power plant. Wade Shictler, City Engr.

Ohio, Cleveland—The East 9th St. Euclid Co., c/o C. H. Beardsley, East 9th St. and Euclid Ave., will install a steam heating system in the 8-story, 70 x 163 ft. office building which it plans to remodel. Estimated cost, $100,000.

Ohio, Cleveland—J. L. Free, 1005 Prospect Ave., will install a steam heating system in the 2 story, 80 x 200 ft. mercantile building which he plans to build on Prospect Ave. and East 21st St. Max Dunning, 1005 Prospect Ave., Arch.

Ohio, Cleveland—The Rialto Amusement Co., c/o P. E. Essick, Stork Theater, West 85th St. and Lorain Ave., will install a steam heating system in the 2-story, 70 x 175 ft. moving picture theater which it plans to build. Total estimated cost, $150,000.

Ohio, Jackson Center—The City Council plans a $15,000 bond issue for public improvements, to include the construction of a lighting plant.

Ohio, Orville—The City Council voted in favor of bond issue of $20,000 for improving and enlarging the lighting plant.

Mich., Detroit—The Holley Carburetor Co., 145 East Willis Ave., plans to build a 23 x 44 ft. boiler house and install separate boiler for heating, forced feed boiler and pump, also motors for power in connection with the factory which it plans to build on Epworth Blvd. and Vancouver St. A. Kahn, Marquette Bldg., Arch.

Mich., Kinde—Bids will be received by W. Brinker, Village Pres., furnishing engine, generator, exciter, switchboard, pole line material, lamps, lamp posts and other material for the complete construction of an electric-light plant. Bonds for $10,000 will be sold for same.

Mich., River Rouge—The Ford Motor Co., Highland Park, plans to build a 2-story, 40 x 80 ft. sub-station and transformer house.

Ill., Chicago—J. S., H. C., and H. Phipps, 787 5th Ave., New York City, plan to build a boiler house in connection with the 1-story, 133 x 520 ft. factory which they will build on 47th and Whipple St. Total estimated cost, $225,000. Marshall Field Co., 22 East Washington St., lessee.

Ill., New Athens — The New Athens Milling Co. plans to rebuild its power house recently destroyed by fire. Estimated cost, $5000.

Minn., Hibbing—Bids will be received until Mar. 10 by C. Foster, Engr., c/o Hibbing Power & Light Co., for the construction of a 3-story, 104 x 158 ft. power house on Main St. A steam heating system will be installed in same. Total estimated cost, $150,000. Halstead & Sullivan, Palladia Bldg., Duluth, Arch.

Minn., International Falls—The city plans to build a pumping station.

Minn., Virginia—The city will receive bids about March 1st for the installation of a heating plant. Plans include the construction of a power plant. Noted Feb. 18.

Kan. Junction City—T. W. Dorn, City Clk., will receive bids until Mar. 10 for furnishing f.o.b. cars, a 50 kw. engine generator set.

Neb., Plymouth—The Beatrice Lighting Co., Beatrice, plans to build an electric-light plant here. B. H. Conlee, Mgr.

Mont., Cut Bank—J. Seal & Son, Great Falls, has applied to the City Council for a franchise to construct a small hydro-electric plant.

Mont., Duluth—The city plans to install a steam heating plant and mechanical ventilation system in the 4-story city hall which it plans to build on West 1st St. Total estimated cost, $1,000,000. L. A. Ayres, City Hall, Engr.

Mont., Miles City—The City Council will install an ash conveyor, 2 new boilers with stoker or self feeding apparatus and a 50-kilowatt generator with turbine motor in the electric-light plant. J. J. McGill, Supt.

Ark., Fort Smith—The Fort Smith-Van Buren Bridge District, 17 North 6th St., will soon award the contract for furnishing materials and reconstructing the power and light circuits on the Free Bridge. W. L. Winters, Engr.

Okla., Berry—The city plans to improve the waterworks and electric-light plant. Estimated cost, $100,000.

Cal., Seal Beach—The city will install a rotary pump and motor and 2 auxiliary booster pumps in connection with the sewerage system which it plans to construct. Total estimated cost, $40,000. Olmsted & Gillelen, 112 Hollingsworth Bldg., Los Angeles, Engr. A. Dyson, City Clk.

Que., Montreal—The Montreal Tramways Co., Ltd., 78 West Craig St., has had plans prepared for the construction of a substation on Cute St. Estimated cost, $400,000. B. Vernon, Royal Trust Bldg., Arch. W. Graves, Tramways Bldg., Ch. Engr.

Sask., Outlook—The Town Council is in the market for a 25 hp. engine and pump to force water to uptown cistern; lift of pump about 30 ft. Thomas G. Colby, Clk.

B. C., Esquimalt — The Department of Public Works, Ottawa, Ont., will receive bids until Mar. 18 for installing a complete heating system, two multitubular boilers, 60 in. diameter, 14 ft. long, electrically driven centrifugal boiler feed pump, etc., in the Military Hospital which it plans to build here. Total estimated cost, $150,000. R. C. Wright, Arch.

B. C., Smithers—The Canadian Pacific Railway, Windsor St., Montreal, Que., plans to build a power house and is in the market for machinery. Estimated cost, $25,000. A. Kilpatrick, Local Supt.

CONTRACTS AWARDED

N. Y., New York—M. A. Hoyt, 28 East 36th St., has awarded the contract for altering the office building at 40-44 Pine St. into a bank, to Marc Eidlitz & Son, 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. Y., New York—The E. K. Stalle Estate has awarded the contract for the construction of a 30-story, 51 x 99 ft. office building on 42nd St. between Broadway and 7th Ave., to Subway Central Building Corp., 1482 Broadway. A steam heating system will be installed in same. Total estimated cost, $1,500,000. United Land & Stores Co., 44 West 18th St., lessee.

N. J., Elizabeth—The United States Leather Co., 856 Magnolia St., has awarded the contract for the construction of a 2-story, 115 x 220 ft. factory, to the Turner Construction Co., 244 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost. $200,000.

Penn., Pittsburgh—The Hein Co., 34 Isabella St., has awarded the contract for the construction of an additional 3rd and 4th story to its power plant, to G. Enziar & Co., 802 Madison Ave. Estimated cost $25,000.

S. C., Greenville—The General Asbestos & Rubber Co., 27 Cumberland St., has awarded the contract for the construction of a 1-story power plant, to the Fiske-Carter Construction Co. Estimated cost. $50,000.

Cal., Fresno—The San Joaquin Light & Power Co., H and Tulare St., will build a 20,000 hp., hydro-electric plant on the San Joaquin River near Macy Flat, to cost $1,750,000. Project includes diversion dam 70 ft. high, 100 ft. long at base and 450 ft. long at top, 2 mi. from present power house; 2 mi. tunnels and 2¼ mi. concrete lined conduits to carry 600 sec.-ft. of water from dam to plant; 3 tunnels, largest 9000 ft. long, cut through solid rock; rock taken from tunnels will be used to build dam and penstock 800 ft. long; will also build roads to proposed power plant on the Kings River where 20,000 hp. plant will be built on Dinkey Creek; one plant will be built each year on Kings River, ultimate plans calling for development of about 200,000-260,000 hp. Complete cost to exceed $55,000,000. Work will be done by day labor.

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire 50-Ft. Lengths
Underwriters' 2½-in.	75c. per ft.
Common, 2½-in.	30%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.55	$0.40	$0.30

Steam—Discounts from List

First grade..... 25% Second grade.....35% Third grade.....40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 30%
Standard..... 40%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	30%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... Llist

For low-pressure heating and return lines { 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	7.2	8½	14½
Fiber or sponge	8	10	6	13	9	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4.75	3½ to 4½	5¼
Gear	4½	9	4½	7.5	7½	9
Car journal	22(gal.)	21 (gal.)	3½	4.9	9¼	8

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20¼
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1.50	$1.49	$1.65	$1.40	$1.66	$1.41
5-gal. cans	1.65	1.49	1.80	1.50	1.86	1.51

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	13.00	14.50	11.25	11.50	13.00	11.00
25- and 50-lb. kegs	13.25	14.75	11.50	11.75	13.25	10.50
12½-lb. keg	13.50	15.00	11.75	11.00	13.50	10.75
1-lb. cans	15.00	16.50	13.25	13.00	15.00	13.00
5-lb. cans	16.00	17.50	13.25	13.50	16.00	13.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. carboys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	40%	45%	45%
Tinned	30%	45%	40%

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6.60 Cleveland...$5.15 Chicago...$5.47 Pittsburgh... 4.65

Coneheads, same sizes:

New York....$5.67 Cleveland...$5.25 Chicago...$5.57 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	37.50 at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	90.00 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL — Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	80.00	93.00	75.00	90.00
Commercial	42.00	50.00	18.50	22.00	15.00	30.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.50
Chicago	19.00	15.00

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼, and ⅜	47%	20½%	¾ to 1½	36%	20%
½	51%	36½%			
¾ to 3	54%	40½%			

LAP WELD

2	47%	34½%	2	29%	15%
2½ to 6	50%	37½%	2½ to 6	31%	18%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	43%	25½%	¾ to 1½	36%	21%
½	48%	35½%			
¾ to 1½	52%	39½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	45%	33½%	2	30%	17%
2½ to 4	48%	36½%	2½ to 4	32%	20%
4½ to 6	47%	35½%	4½ to 6	31%	19%

Stock discounts in cities named are as follows:

	New York- Black	New York- Galvanized	Cleveland- Black	Cleveland- Galvanized	Chicago Black	Chicago Galvanized
¾ to 3 in. steel butt welded	43%	27%	43%	26%	44.9%	29.9%
3½ to 3 in. steel lap welded	38%	23%	39%	23%	40.9%	26.9%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%. Cast iron, standard sizes, 10% off.

BOILER TUBES — The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	37	3½ to 4½ in.	15½
2½ to 3¼ in.	27	3 to 3¼ in.	+ 2
2¼ in.	20½	2½ to 2¾ in.	+ 4½
1¼ to 2 in.	16	2 to 2¼ in.	+19½
		1¾ to 1⅞ in.	+32

Standard Commercial Seamless—Cold Drawn or Hot Rolled

Per Net Ton		Per Net Ton	
1 in.	$334	1¾ in.	$214
1¼ in.	274	2 to 2¼ in.	184
1½ in.	264	2½ to 3¼ in.	174
1¾ in.	214	4 in.	194
		4½ to 5 in.	214

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$222.00
No. 12 solid	135.00	170.00	211.00	290.00
No. 10 solid	185.00	235.00	255.00	325.00
No. 8 stranded	235.00	325.00	345.00	450.00
No. 6 stranded	370.00	472.00	625.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜	.....	.....	$18.24	$19.38	$5.76	$6.12
½	$76.50	$81.60	18.24	19.38	6.72	7.14
¾	101.20	108.10	24.00	25.50	9.60	10.20
1	149.60	159.80	35.52	37.74	12.48	13.26
1¼	202.40	216.20	45.45	48.15	17.17	18.19
1½	242.00	258.50	60.60	64.20	21.21	22.47
2	325.60	347.80	111.11	117.70	28.28	29.96
2½	514.80	549.90	181.80	192.60	40.40	42.80
3	673.20	719.10	484.80	513.60	60.60	64.20
3½	837.20	892.40	1,070.60	1,134.20	80.80	85.60
4	1,013.70	1,079.10	1,237.25	1,310.75	101.00	107.00

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	Coils...55% Off.. Less coils, 40% off
½	250	.06	
¾	250	.09	
1	200	.12	
1¼	200	.15	
1½	150	.18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T. P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	28.40
No. 18 cotton parallel	25.00
No. 16 cotton parallel	32.00
No. 18 cotton reinforced heavy	35.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.00
No. 18 cotton Canvasite cord	29.00
No. 16 cotton Canvasite cord	35.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
10-amp. to 200-amp.	25	2.00
25-amp. to 400-amp.	25	3.60
2-map. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 30%; 1-5th to standard package 40%; Standard package 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5.25 C
0-30 ampere, less than standard package	7.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B—Watts	Plain	Frosted	No. in Package	Mazda C—Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$13.00	$16.00	$18.00	$32.00
12	16.70	18.80	22.00	36.85
10	23.52	26.10	29.10	50.60
8	31.00	36.40	40.20	70.10
6	.....	.....	62.00	.....
4	.....	.....	83.10	.....
2	.....	.....	122.40	.....
1	.....	.....	161.30	.....
0	.....	.....	189.68	.....
00	.....	.....	230.00	.....
000	.....	.....	282.40	.....
0000	.....	.....	345.50	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15.00	$19.00	$38.40	$21.00	$16.00	$33.00	$12.00	$17.35	$29.90
10	22.65	29.05	58.25	27.20	31.00	69.00	23.10	23.60	52.80
8	31.95	39.20	78.65	38.00	42.00	78.00	32.10	41.10	.....
6	54.40	58.10	.....	.....	65.00	130.00	55.40	65.90	.....
4	77.50	83.00	.....	.....	93.00	.....	72.65	90.00	.....
2	115.30	123.50	.....	.....	140.00	.....	115.00	129.50	.....
1	150.05	161.20	.....	.....	182.00	.....	155.60	168.50	.....
0	.....	179.05	.....	.....	242.00	.....	199.50	219.00	.....
00	.....	243.35	.....	.....	290.00	.....	245.50	261.50	.....
000	.....	296.65	.....	.....	360.00	.....	299.50	317.00	.....
0000	.....	361.50	.....	.....	435.00	.....	356.00	378.50	.....

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package +20%; 1-5th to standard package +10%; Standard package −15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	45c. lb.
No. 18 B.&S. regular 1-lb. coils	47c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%